THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

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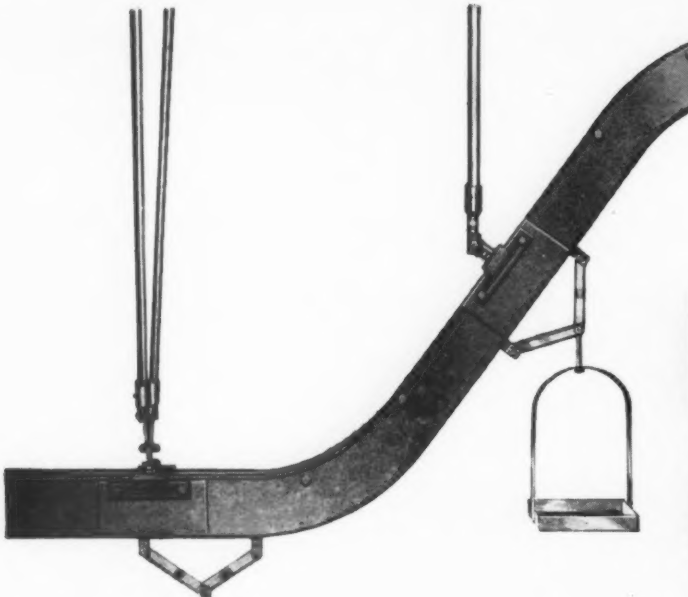

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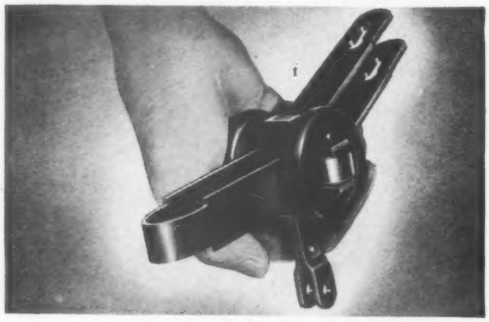

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UNBRAKO

The Annual Dinner, 9th October, 1953

The series of leading articles on "Universals of Production" is interrupted this month to allow publication of the Address given by the Right Hon. Viscount Waverley, P.C., G.C.B., G.C.S.I., G.C.I.E., at the Institution's Annual Dinner in the Guildhall, London.

Lord Waverley was replying to the toast of "The Guests", proposed by the President of the Institution, Mr. Walter Puckey.

"AS I am supposed to be replying for the guests, I must begin by thanking you, Sir, for your very interesting speech and for the kind things that you have said about the various categories of guests who have come together at your bidding this evening.

"In what I have to say I am addressing primarily engineers, and I think that I ought to begin with a confession, because I used until quite recently to think that the engineers of this country had laid themselves open to criticism, if not to reproach, by reason of the (as it seemed to me) excessive proliferation of professional bodies set up within the profession on a sectional basis. I have to some extent changed my view; I would not, if there is indeed ground for reproach, wish to include the Institution of Production Engineers. If I had any such inclination, it would only be necessary for me to look round this remarkable gathering to dismiss it from my mind.

"I have in fact, however, had the opportunity, through the kindness of your President, of learning some things that I did not know before about your Institution. I have learned of your various activities during your comparatively short life, and I have been greatly impressed by your history, short though it is, and by your record of achievement.

"I know that some fifteen years ago you instituted researches at Loughborough into production engineering, researches which have now been entrusted to one of those Associations with which I was so closely concerned when I was Lord President of the Council, a development which is, or was until quite recently, unique in the world, and on which this country can reasonably pride itself. You have what you call 'P.E.R.A.', the Production Engineering Research Association.

"I received recently a very weighty parcel—I looked at the postage, and it came to something like three shillings—containing recent publications of your Institution. Having looked through the contents of that parcel, I have learned of the many fruitful studies that have been pursued under the aegis of your Institution into such matters as measurement of productivity, in conjunction with the Institute of Cost and Works Accountants, into management, production and rearmament, in conjunction with the British Institute of Management, whose Chairman I see here this evening, and into the use and handling of materials, and so on. I have learned also that you have established a really high standard of qualification for membership of your Institution, and upon that I congratulate you. (*Applause*)

"But, gentlemen, this Institution, it seems to me, deserves to be supported not merely, or indeed primarily, for the reasons that I have just briefly indicated. It deserves to be supported primarily, as I think, because of the vital importance in these days of production. It is on production that the maintenance of our standards of life, and indeed the maintenance of our economic life as a nation, are absolutely dependent.

"The exports which used to be the mainstay of our foreign trade have dwindled sadly in various directions—textiles, and coal, the export of which on a great scale would make a tremendous difference to our balance of payments, but which has dwindled to insignificant proportions. We have to look in other directions, and we have to face keener and ever keener competition.

Production and Productivity

"I noticed in the Press only this morning that our Chancellor of the Exchequer had expressed satisfaction with an increase of production of, I think it was, 5 per cent. But quantity is not everything. We have to make goods that people will buy, and we have to offer them at prices which people are willing to pay. That raises a question of productivity, to be distinguished from production; productivity, which depends on the relation of the value of production to the resources of materials and man-power used up in the process of production.

"Now, as you all know, various factors, all essential, enter into the process of production—research, development, leading up to the final stage of production, with problems of operation and design coming in between the last two, between development and production. All those factors must be kept in balance, with the most economic distribution of resources between the different stages. There is indeed—if I may venture to say this to you, who know much more about these things than I do—much to be lost by allowing any one stage to get out of equilibrium with the others.

"It has been customary to extol the achievements of this country in pure research, and at the same time to deplore our supposed lack of success in the application of the results of research. I think, and I venture to say, that such criticism is not quite fair, at any rate in these days. We have certainly led the world, as would, I believe, be universally acknowledged, in scientific discovery in the physical and the biological sciences and engineering, but what about radar, jet propulsion, new fibres, dyestuffs, therapeutic agents, and so on? These things have been not only discovered, but developed here with conspicuous success. (*Applause*)

Emphasis on Technology

"There was a time when the pure scientist was inclined to look down his nose at applied science, pursuing truth for its own sake and brushing economic arguments contemptuously aside. I expect that many of you know the story of Faraday proudly claiming that his elucidation of the principles of electromagnetic induction, actually the foundation of the whole electrical industry of this country and of the world, could be of no practical value. On the other hand, you had one of our greatest men of science of modern times, Rutherford, devoting, I believe, his early years at Cambridge, to which he came from McGill, to the study of electromagnetic waves because of what he believed to be their economic possibilities. He thought, and made no secret of it, that there might be money in it, and he was looking forward to getting married. I think that Rutherford's example is one to be followed. (*Applause*) I believe that the emphasis on technology today will in the course of a comparatively short time result in the elimination of any lingering traces of the old prejudices.

"Following upon development, with some overlapping, comes the stage of production, with operational tests and problems of design intervening; and there, it seems to me, the production engineer enters the picture, with all his new techniques of work study, motion study, measurement of work, the utilisation of materials, mechanical handling—which we are greatly interested in, as the President has remarked, in the Port of London—factory organisation, the introduction and application of incentive schemes and so on.

"There the same need arises of keeping the various stages of the production process in harmony. There is always a tendency for design to become more and more complicated, and there results a danger that development may become antagonistic to production. That is a very real danger. I can well remember, during the War, hearing bitter complaints of continual changes in detail and consequent setback to the production of prototype aircraft for which we were desperately anxious. I am inclined to ask myself whether therein may possibly lie the explanation of the withdrawal of the *Valiant* aircraft from a recently organised competitive test. I do not know, but it seems to me to be a possibility that excessive time may have been given to development at the expense of production.

"Then there is the question of human relations, which is very relevant to the introduction of labour-saving devices. Organised labour in this country has bitter memories of past exploitation. We must face that, and that is a matter, as it seems to me, with which the Production Engineer must concern himself.

Production Engineering and Management

"These things which I have mentioned are not, of course, the whole story. There is always the question of salesmanship, though that is perhaps a matter for another day. I am thus brought to my final point, the relation of production engineering to management. I read constantly, in the correspondence columns of the Press, the view expressed that industry would be healthier if only there was more technical experience in the higher managerial ranks and on boards of directors and so forth. I can think of many most highly competent men of science, wonderfully valuable in their own sphere, who would make terribly bad managers and who would not be an acquisition on a board of directors. The claim is one which is perhaps put forward most frequently in regard to scientists, but, like most generalisations, it is only partially true.

"There is no doubt, I think, that management has a technique of its own. It is surely equally true, however, that in industry and commerce, unlike essentially technical pursuits, there should be more than one avenue to the top, and I would say personally that the more the better. I should like to see it laid down and universally recognised that law, accountancy, administration, science, engineering, all these disciplines—I omit politics for the moment (*Laughter*)—are the equivalent of the corporal's knapsack in which the field marshal's baton may be found. (*Applause*) None of these disciplines, I am sure, could be better from the point of view of management than the discipline and training of the Production Engineer.

"For that reason it gives me very great pleasure to be here this evening and to be in a position to respond on behalf of your guests in this remarkable gathering to the toast which the President has so kindly proposed."

Prior to Lord Waverley's Address, SIR ROWLAND SMITH, proposing the toast of " The Right Hon. The Lord Mayor, The Sheriffs and The Corporation of London ", said :

" By the generosity of the Lord Mayor the Institution has the privilege of holding its Annual Dinner in Guildhall, which for centuries has been a symbol of commerce, industry and hospitality. No one can remain unmoved when taking part in such a ceremony in a hall in which a long line of Lord Mayors have entertained their guests for more than five hundred years. We have only to conjure up a mental picture of the incidents which must have taken place within these walls to realise that we are very privileged to be holding our Dinner here this evening." (*Applause*)

That the Lord Mayor, in the midst of his arduous duties in Coronation Year, had given the time to honour the Institution by his presence was a source of pride and gratification to the President and Council of the Institution, continued Sir Rowland, for which they wished him to tender their thanks and appreciation. (*Applause.*) That great Londoner, Dr. Johnson, once said : " He who is tired of London is tired of life." Despite the great strain which his arduous duties in Coronation Year must have imposed upon him, it was easy to see that the Lord Mayor, with his buoyant spirit and his versatility, would never tire of London. As evidence of his versatility, he had recently travelled on one of his official duties on horseback.

" Since the manufacture of motor cars comes within the orbit of the Institution of Production Engineers and the breeding of horses does not," Sir Rowland Smith remarked, " it might be good public relations for me to express the hope that the example which Sir Rupert has set will not be a pattern for his successors in office." Such equestrian exploits formed only a tiny part of the Lord Mayor's real interests, but when the debates at Westminster were more than usually tedious no doubt he would think with a certain regret of the beautiful pastures in his constituency in the Vale of Evesham or of his farm in a pleasant part of Sussex.

It was with very great pleasure that Sir Rowland proposed the toast of the versatile Lord Mayor of London—Baker, Skinner, Sailor, Soldier, Airman, Gentleman—and of Mr. Sheriff Tremellen (unhappily Mr. Alderman and Sheriff Stockdale was prevented from attending) and of the Corporation of London. (*Applause*)

The Rt. Hon. The LORD MAYOR OF LONDON (Sir Rupert De la Bère, K.C.V.O., M.P.), who responded, thanked Sir Rowland Smith for the very charming words in which he had proposed the toast and said that he would like, in briefly replying to it, to say a word on the employment of older folk in business, a very important topic. In the recent World War there had been very little opportunity for apprenticeship to be carried on, and to-day the country needed every skilled man it could get. The question of emigration entered into the problem; the Dominions wanted our skilled young men and were reluctant to take those less skilled. Were we to let these skilled men go, and, if so, in what numbers ? Ought we not to employ all our skilled men who were fit and willing to work, even if they were over age ?

In considering this problem he had sought advice from the Continent, and there he had been told that the British race had a positive genius for compromise. He took that as a compliment. It was not possible in this matter to lay down hard and fast rules for any industry, but he believed most sincerely that every endeavour should be made to employ all our really skilled men who were fit and willing to work, even if they had reached a certain age, because we had some magnificent craftsmen in this country and we ought to make full use of them. (*Applause*)

" I have been ' chipped ' a little," Sir Rupert said, " because in order to show my Canadian friends that I like horses—and Canadians—I rode a Canadian Mountie horse. I shall go on riding horses; but if the proposer of this toast will allow an ordinary man like myself to acquire one of those charming vehicles which he makes, at the very modest price at which they are advertised, but which you cannot get, I will ride in that. (*Laughter*) I hope that in 1954, when I am out of office as Lord Mayor, I shall be seen proceeding to Westminster in one of these vehicles. It would not be in accordance with the traditions of Guildhall to give the name of the vehicle, and nobody will guess ! " (*Laughter*)

He had greatly enjoyed spending the evening in such a friendly gathering. It was unusual to see in Guildhall such a cross-section of a great industry. Often when he spoke he found himself talking to virtually the same audience and with only a different name for the banquet, but there was present that evening a cross-section of almost the whole of the engineering industry, and it was a great privilege to address them.

" I believe in the old statement," he said in conclusion, " that what we want is courage, imagination and industry. We have imagination, we have industry, and, my God ! we certainly have courage. (*Applause*) In life, if you think you are beat, well, you are beat, but if you think you are unbeatable, you *are* unbeatable. This country, with all its past history, is unbeatable. It will regain what it had to give up during the War, and this nation, which has never really known defeat, but which has often had set-backs, will go on to show the world that it stands for something worth while, the survival of home life and all that we have in spiritual values; for in home life and in spiritual values this country is a great leader still, and will always remain so." (*Applause*)

WELDING JIGS AND FIXTURES FOR PRODUCTION OF RAILWAY ROLLING STOCK

by P. J. HENNEKER

Presented to the London Section of the Institution, 12th March, 1953

Mr. P. J. Henneker

Mr. Henneker was trained in the S.E. & C.R. Locomotive Works at Ashford, Kent, and, after serving in the First World War, he spent a period at the Royal Small Arms Factory, Enfield. He then returned to Ashford and later took charge of wagon production in the Southern Railway Works.

In 1950, he became Assistant to the Works Manager of the British Railways Carriage and Wagon Works, Ashford.

LIVING in a world of keen competition, and faced with the necessity for increased production in all phases of our national life, it is essential that full advantage be taken of the knowledge placed at our disposal, whether it be scientific, technical or practical, to achieve the desired ends. This applies particularly to all branches of the engineering industry.

A great wealth of information has been written, and tremendous strides are being made so far as the scientific and technical aspect within the industry is concerned, but I feel the practical side, or, if I may coin the phrase " getting right down to the floor of the production shop ", has been somewhat neglected.

Experience, that unique knowledge, stored away in a man's mind, gained by difficulties encountered and overcome, day by day, plays a vital part in present day engineering production, especially with the increase of mass-producing methods. So I intend in the short time at my disposal this evening, to make some observations on that important subject, jigs and fixtures for production by welding, for their use is essential for ease in movement of fabricated structures, and to obtain correct positioning and good accessibility of welds.

In this connection I am dealing principally with jigs and fixtures as used in the construction of the underframes of railway carriage and wagon stock, and whilst I appreciate that some of those present may be chiefly interested in small welded fabrications, the construction by welding of this particular class of work covers a wide range, from small sub-assemblies to the final heavy construction.

To clear any confusion as to the difference between a jig and a fixture, a jig may be described as a device other than a template for guiding a machining or manufacturing process, so that the required dimensions are conformed to without specific measurements being made, whilst a fixture is a device for holding an article or machine so as to facilitate a specific machining or manufacturing process. It is often difficult to distinguish between the two, but it may generally be said that the ultimate purpose of such equipment is to eliminate the repetition of measuring, marking-off or setting-up in connection with multiple production, thus conserving the time of skilled staff and reducing costs, whilst at the same time tending to produce articles that are standardised and interchangeable.

Now, the design and construction of really effective jigs or fixtures requires careful planning and a detailed study of manufacturing procedure, and thus the success or failure of the final construction depends largely on the skill and initiative of the Production Engineer.

So many problems present themselves in the initial stages of any form of construction, which have a vital bearing on the design of jigs and fixtures to be used and their sequence of operation, that I suggest we spend a few minutes considering them.

Drawings of a new welded structure require careful attention to ascertain the size and type of welds, their location and accessibility in manufacture, and it may be necessary to make recommendations for alterations to drawings to make for rapid output.

Other influences which affect the design of jigs and fixtures to be used are the rate of production required and floor space available. The latter governs the time allowed for each operation and, therefore, the size and number of fixtures required. It is often advisable

to break down the main assembly into as many sub-assemblies as possible, thus facilitating handling of component parts, lessening possible distortion when welding the main assembly and, above all, preventing undue waste of welding time.

Again, it may be economically sound to introduce automatic or semi-automatic welding machines, and it is always profitable to be well informed of the latest equipment as it appears on the market. The people responsible for its manufacture are always willing to place their services at the disposal of the trade.

Design of Jigs and Fixtures

When satisfied on these points, it is possible to begin designing the jigs and fixtures required. There is no hard and fast rule for this; good common sense, coupled with practical experience, are the deciding factors. The work should not be rushed and the final design should take shape from rough sketches. The operator should be pictured at work on the sub-assembly concerned.

The jig or fixture should be made as simple and foolproof as possible, without sacrificing efficiency and, should the fixture become complicated by having to hold a number of components, particular care should be taken to ensure that it is easy to withdraw the welded structure after completion. Distortion, should it occur, will also make withdrawal difficult—another point to bear in mind.

Jigs and fixtures for welding differ from those used on machine tool work in that fine polish and finish, the pride of the toolmaker, are less necessary. They are usually of plain construction and often made from scrap rolled steel sections, one qualification being that location stops must be correctly positioned and, if machined, protected from weld-spatter.

It is often wise to discuss the design freely with the operators who have to use the jigs or fixture. Not only may a more effective design be achieved thereby, but there is a tendency to create interest and a sense of responsibility among the operators.

All clamping devices and location stops should, if possible, be placed where the operator can see them, and it should be remembered that clamping the work to the fixture can become very fatiguing. Clamps should, therefore, be simple and as easy to work as possible, and for very rapid production adoption of pneumatic clamping devices may be advisable. Care must also be taken to position clamps so as to avoid springing the work.

It may be possible to accommodate several sizes of a similar design of structure by incorporating in the fixture adjustable location points.

Use of Distinctive Colours

It is a good plan to paint a jig or fixture a distinctive colour, for it is not unknown for an operator to weld the work to the fixture.

It may be found necessary to use a positioner or manipulator, for it must be borne in mind that the fundamental condition for the efficiency of welding as a production method is largely dependent on ease in handling fabricated structures in order to obtain correct positioning and good accessibility of the welds.

Every weld should, as far as is practicable, be made in the downhand position thus reducing to a minimum fatigue of the operator and possibly enabling welding time to be reduced by the use of larger electrodes, whilst enabling much of the work to be carried out satisfactorily by operators not possessing a high degree of skill.

For a large or heavy fabrication, particularly if it is cylindrical in form, it may be advisable to use a roller-mounted manipulator. The jig or fixture may be enclosed in wings which revolve on rollers. Such equipment is liable to become complex and expensive, however, and in a particular scheme with which I shall be dealing in detail later, the idea of using large manipulators was rejected in favour of static jigs and fixtures, in which the work was positioned by means of overhead lifting gear.

One of the most difficult problems encountered in fabrication by welding is distortion, and whilst the causes, effects and means of counteracting distortion do not come within the province of this Paper and would provide the subject for a Paper on their own, one or two observations may be appropriate in relation to the design of welding jigs and fixtures.

In a number of instances possible distortion can be anticipated and counter measures taken. Suitable allowance can be made when locating positioning stops and arranging the components of the structure. The sequence of welding is also of the greatest importance, as it is often possible evenly to distribute the heat that has got to be put into the structure, rather than concentrate it in a restricted area. Again the jig or fixture can be so designed that with the aid of mechanical appliances, distortion may be resisted.

Should distortion have occurred in the completed structure, the only remedy is some form of heat treatment.

I will now endeavour to explain more fully some of the points I have mentioned, dealing first with the simpler type of fixture and proceeding to more complicated designs. I have taken as examples a number of welding jigs and fixtures used on railway carriage and wagon construction. Some may appear crude in construction but they have been made for hard wear, and I can assure you they get it. As they come out of service, modifications and improvements are made in the light of experience gained, whilst others are scrapped. It should be remembered that even for comparatively small quantities of welded fabrications of the same design, not only is a jig or fixture essential for easier handling of component parts, but the cost of its construction is negligible compared with the results achieved.

Fixture for Covered Goods Wagon Door Hinge

Many railway covered goods vehicles are fitted with four doors each supported by two hinges, and Fig. 1 shows a simple but effective method of holding the boss or bolt end of the door hinge, and

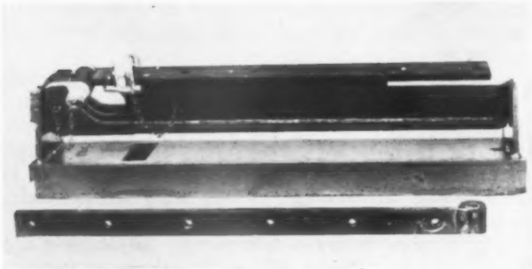

Fig. 1

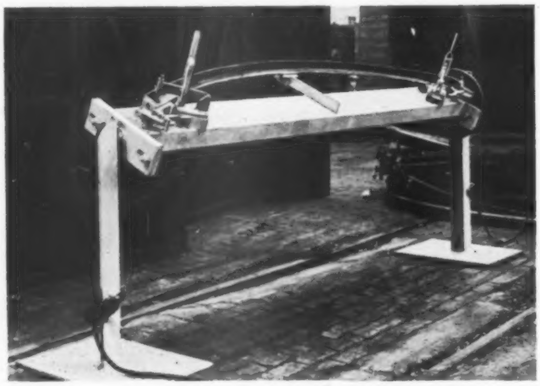

Fig. 2

Fig. 3

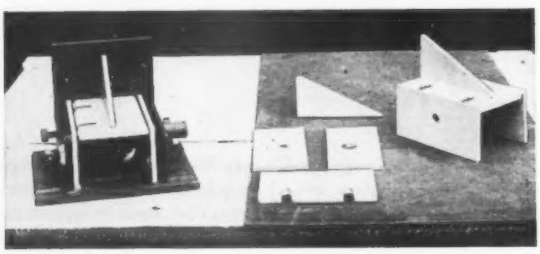

Fig. 4

the hinge bar for welding. For location purposes advantage is taken of the bolt holes already jig-drilled in the hinge bar for bolting to the door.

The fixture is constructed of a short length of rolled steel joist, one of the flanges being used as a base, and in this two dowel pins are fitted for positioning the hinge bar. At one end of the steel joist, two plates are attached, designed so as to allow ample clearance for welding, and drilled so that combined, they form a double-eye, in which the bolt end is located and held by a turned pin passing through the holes in the plates. The hinge bar is held by a steel tapered cotter, passing through two lugs welded to the base. The fixture rotates as required on the trunnion plates attached to the supporting channel. The two components are welded with no preparation.

Fixture for Welding Fastening Lugs to Roof Irons

Fig. 2 shows a fixture for welding the fastening lugs to the ends of roof supporting angles. Mounted on trunnions, it is constructed of 9″ x $3\frac{1}{16}$″ channel, the web forming the base. At one end a steel disc is attached, made to lock at any angle when welding is taking place. The small platforms at either end of the base are each fitted with a dowel pin to locate the roof angle, advantage being taken of the bolt holes already jig-drilled.

Two large quick acting toggle clamps hold the angle, whilst the fastening lugs, mounted in their respective positions, are held by smaller clamps of the same design. A feature of these clamps is that any thickness of material within a certain range can be accommodated and held firmly by adjustment of the holding down set screw.

Fig. 3 shows a close-up view of the clamping arrangement.

Fixture for Fabricated B.R. Standard Carriage Vestibule Buffer Guide Bracket

The B.R. standard carriage vestibule buffer guide bracket consists of six pieces of plate, four of which, when welded together, form a rectangular housing (as may be seen in Fig. 4) through which the vestibule buffer stem passes, allowance being made for a tapered wedge for adjusting purposes. Two plates, one at the back for fastening to the headstock, and the other on top, acting as a support for the vestibule gangway, complete the assembly. The fabrication of the structure is made in two operations.

First Operation

The fixture in which this bracket is assembled is constructed of two plates, welded together at right angles, forming a base and back plate. On the base plate there is a small box-like mounting, flanked on either side by a short length of angle for clamping purposes (Fig. 14).

Method of Assembling

The two small side plates of the housing are placed one on each side of the mounting and held by set screws provided in the adjacent angles, whilst the

top plate rests between the two. A turned pin passing through holes in the angles and side plates positions the assembly. Two dowel pins attached to the back plate locate the web.

Second Operation

The top and end plates are located on a fixture, shown in Fig. 5, by utilising the holes already drilled in them, and the housing shown in Fig. 4 is positioned on them by means of a stop projecting from the back plate of the fixture. Tack-welding is then carried out and the assembly is removed from the fixture for completion.

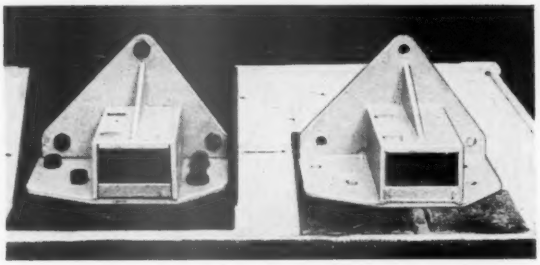

Fig. 5

Fixture for Tack Welding Wagon Buffer Trimmers

A buffing trimmer is a short, stiff strengthening member of a wagon underframe, situated between the outer solebar and inner diagonal member. Its function is to support the buffer stem and take the initial buffing load, due to impact with other vehicles.

The fixture for its construction (see Fig. 6) consists of a base plate with two vertical supports, carrying a top plate. The small structure in the centre of the fixture, supports the web plate.

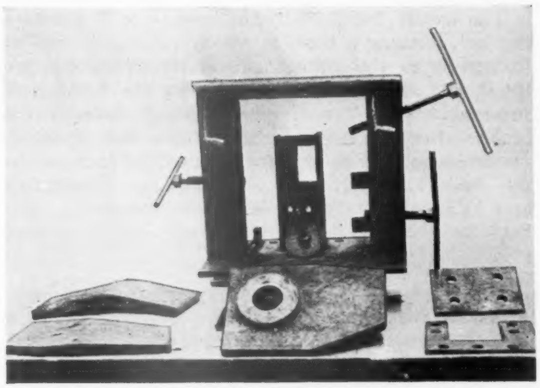

Fig. 6

Method of Loading

There are five component details to be accommodated: first, the solebar fastening plate is placed on the base, resting between the locating stops provided and held by four taper pins passing through the fastening holes already drilled in the plate and corresponding holes in the base of the fixture; next, the web plate, with boss attached, located by the two small dowel pins, is fitted in the centre structure contacting the buffer hole of the plate and secured by the screwed cap against the boss face. The top and bottom plates are then placed in position, located from the base and held by the tee bolts provided in the vertical supports. Lastly, the diagonal fastening plate is mounted on the top of the assembly and held by a set screw to the top plate of the fixture.

Fig. 7 shows the fixture loaded and a completed buffer trimmer.

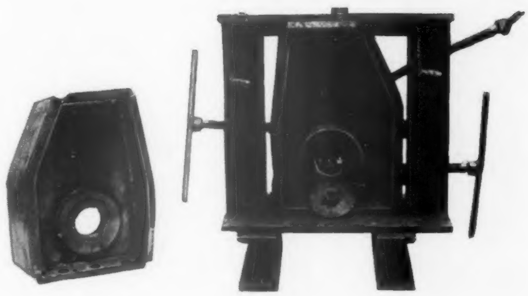

Fig. 7

Fixture for Prototype Brake Shoe

In Fig. 8 is seen a prototype brake shoe, comprising six pieces of $\frac{1}{2}''$ plate, two curved and machined with a square hole to fit the brake block refill, and four strengthening gussets. The shoe itself is manufactured complete in one fixture but in two sections, similar in design, except that one is larger than the other and drilled to take the brake block hanger.

The fixture, a fabrication with the base plate curved to suit the profile of the shoe faces, is fitted with square projections for location purposes. In the centre a replica of the brake beam end is constructed with two lugs drilled to locate the brake hanger pin.

Fig. 8

In loading the fixture, the shoe faces are located by the square projections on the base, whilst the gusset plates rest, two on each side of the inclined plate at the centre between guide studs. The moveable arm is then lowered and locked by a quick-acting eccentric clamp, holding the assembly firmly.

Fixture for Welding Brake Shoe and Brake Beam Assembly

In Fig. 9 is shown the method for assembling the brake shoes and the brake beam. The beam itself, a fabrication, made from ¾″ flat bar suitably profiled and strengthened by a stiffening strip along the outer edge, is drilled with a series of holes for brake adjustment.

The fixture, made to rotate, is of 6″ x 4″ channel, the web forming a base, to which mountings, similar in design to the fixture previously described, are fitted, one at either end, for locating the brake shoe sub-assemblies. Dowel pins passing through the brake adjusting holes in the beam and specially prepared holes in the fixture, locate the beam, whilst the shoes are positioned by the square projections and locating strips provided in the mountings, and held by steel tapered wedges driven firmly against stops on the fixture.

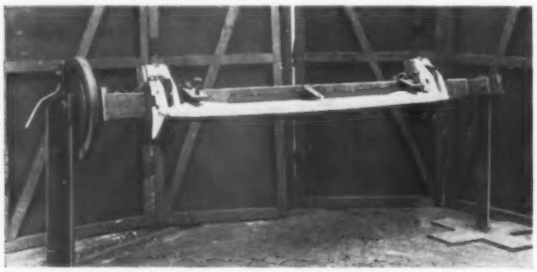

Fig. 9

The Shock Absorber Wagon

A shock absorber wagon is a specially designed vehicle for carrying fragile freight. When it is considered that British Railways carry approximately one hundred million tons of merchandise per annum, excluding coal and iron ore, it is inevitable that instances of damage to goods in transit occur. Efforts have been, and are being, made to minimise this, and the introduction of the shock absorber wagon, both open and covered, is an example. A covered vehicle of this type is illustrated in Fig. 10.

The principal feature of the design of these vehicles is that the body, instead of being integral with the underframe, is constructed as an independent unit, mounted so as to have a limited amount of longitudinal travel on the underframe. The movement of the body is controlled by springs acting horizontally on brackets on the main underframe and the sub-frame of the body, thus absorbing some of the shock due to impact of the buffers. For the purposes of this Paper, we are only concerned with the fixtures for fabricating the auxiliary spring hanger bracket and the construction of the sub-frame of the body.

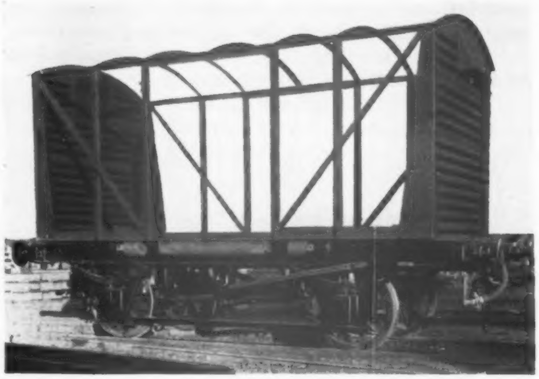

Fig. 10

Fixture for Welding the Shock Absorbing Spring Bracket

Fig. 11 shows the details of the bracket, a completed assembly, and the fixture loaded.

The details, four in number, comprise the body of the bracket made from ¾″ mild steel plate suitably shaped, a large washer to take the thrust of the absorber spring, a small washer, through which the guide spindle of the spring passes when assembled, and a small guard lug.

The fixture, made from scrap off-cuts, consists of a base plate, to which is attached a small section of 9″ x 3″ channel with locating strips welded on the inside face of the flanges for supporting the body of the bracket.

The position of the bracket in the fixture is governed by the two small vertical strips attached to the base. A turned pin, slotted to take two steel tapered cotters, accurately positioned by the holes in the outer vertical supports, locates the large and small washers. By tightening the cotters the assembly is held firmly. The hinged piece, attached to the right hand vertical support, locates the guard bracket.

Fig. 11

Fixture for Fabricating the Complete Solebar Assembly for Shock Absorber Wagon

The assembly consists of the 9″ x 3″ x 17′ 6″ outer channel, or solebar, of the main underframe to which are attached two auxiliary spring brackets

and two shock absorber spring compressor brackets. Holes drilled in the channel for other details are used for location purposes. The fixture, constructed from 9" x $3\frac{1}{16}$" channel and embodying a King-post to prevent sagging, is mounted on pedestals with a locking device at one end for setting at any angle when welding. This may be seen in Fig. 12.

Four pairs of stops, welded to the flange of the fixture, locate the brackets. Two pairs for the auxiliary spring brackets are drilled to take a turned pin which passes through the holes in the washers, whilst the compressor brackets are held in the other two pairs by means of a locking bar. This is clearly seen in Fig. 13.

As a precaution against any discrepancy in the rolled steel section, such as twist or other distortion, the solebar is securely bolted to the base of the fixture by four bolts, two at either end.

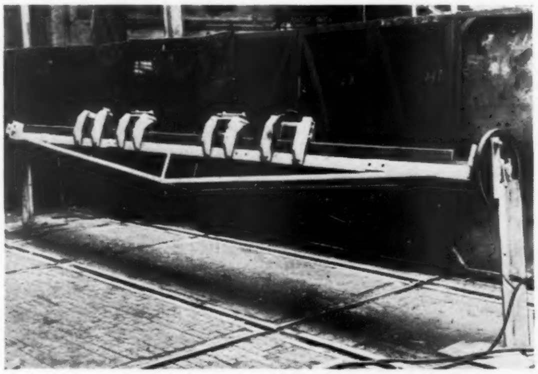

Fig. 12

Shock Absorber Wagon Sub-Frame

Fig. 14 shows the sub-frame of a shock absorber wagon, constructed principally of 4" x 3" channel, with the exception of the outer side rail which is 3" x 3" angle, strengthened in the doorway by a stiffening plate.

The complete structure is made in two operations, (A) the two outer sections, each comprising the inner longitudinal and outer side rail with their respective transverse members and (B) the complete sub-frame structure.

In Fig. 15 is shown the fixture for assembly (A) made from a length of 10" x 3" channel, the web being used as a base plate, to which are attached the necessary locating stops. The fixture is capable of rotating on pedestals. To one of the flanges of the channel base two quick acting toggle clamps are fitted for holding the doorway stiffening plate. On the other flange four positioning brackets are bolted.

Method of Loading Fixture

The four positioning brackets are first released to allow freedom of movement when assembling. The side rail angle and longitudinal channel are then fitted against the stops provided. Dowel pins passing through the holes drilled in the members, locate them correctly. The transverse members, the ends

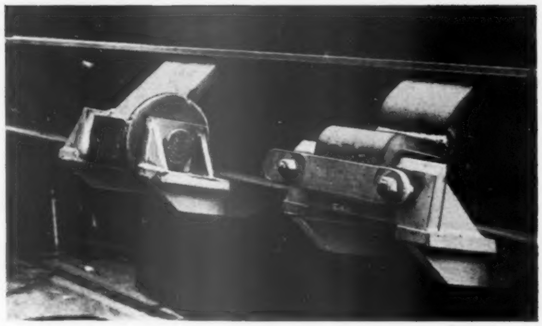

Fig. 13

of which are profiled to fit the inside section of the channel, are next placed in position and the assembly completed by tightening the four brackets attached to the flange of the fixture. To ensure perfect horizontal alignment, four clamps hold the assembly to the fixture.

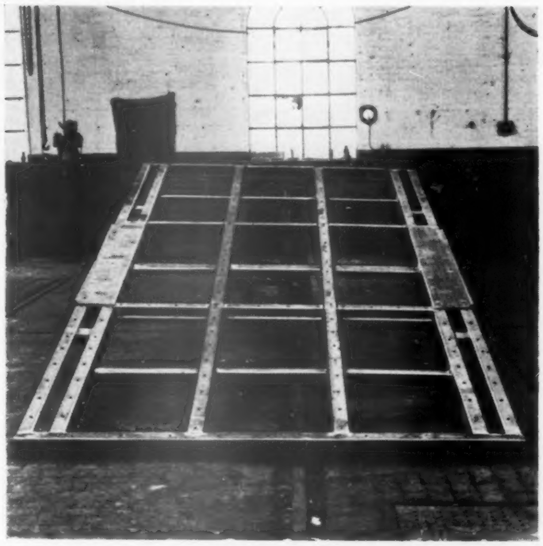

Fig. 14

Assembly (B) of the Sub-Frame

Fig. 16 shows the fixture for the complete fabrication of the sub-frame, constructed chiefly from 6" x $3\frac{1}{2}$" channel, and equipped with the necessary supports, stops and clamping devices.

To load, the two sub-assemblies previously described are first placed in position, followed by the centre longitudinals and end channels, the holes for the floor plates being used for locating. The fitting of the transverse members completes the assembly.

To ensure that the profiled ends of the various members fit tightly in position, wedges are driven firmly between the ends of one end channel and stops provided.

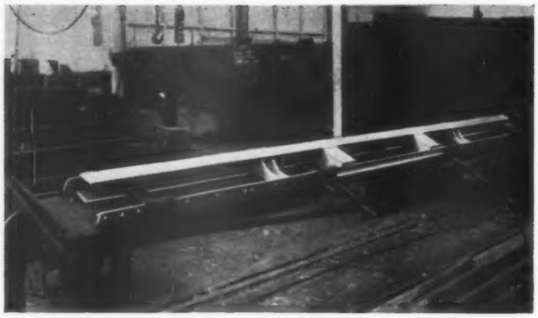

Fig. 15

British Railways Standard Carriage Underframe

Fig. 17 enables me to enlarge on my earlier observations concerning the problems which confront the Production Engineer in the initial stages of any new constructional scheme, and the various influences which have a vital bearing on the design of jigs and fixtures to be used.

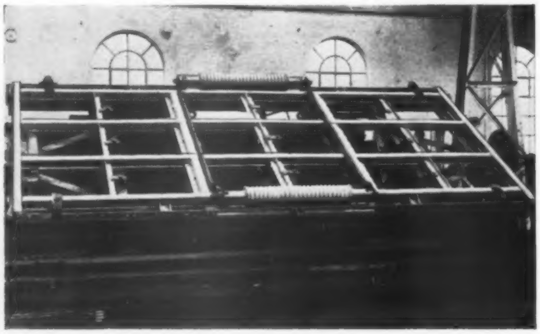

Fig. 16

As you are aware, one of the great advantages of British Railways under nationalisation has been a certain degree of standardisation of rolling stock, and the British Standard carriage underframe is of great interest in connection with our subject.

In the development of this underframe, close liaison was maintained between those responsible for the design and those concerned with production, with a view to minimising difficulties in manufacture.

The underframe for corridor stock is 63′ 5″ long (over headstocks) and 7′ 11½″ wide, and is designed to withstand an end compressive load of 200 tons. The strength of the structure lies mainly in the centre longitudinal trussed members. Cantilever outriggers mounted on the outside of these carry the outer longitudinal members or solebars. The load from the side buffers is transmitted to the centre longitudinals through diagonal abutments. The underframe is constructed with an upward camber of $\frac{1}{2}'' \pm \frac{1}{8}''$ measured from end to end.

Extensive use is made of British Standard rolled steel sections and an interesting feature of the design is the use made of "Tees", enabling adequate welding attachment to be obtained without the use of gusset plates. Their use also assists in the preparation of the majority of the component members for assembling with the minimum of fitting by enabling the ends to be profiled and bevelled by flamecutting.

Having said so much on the general design of the structure, we now come to planning its construction. From experience, I have come to the conclusion that, if possible, it is preferable, when planning for a given project, to allow a reasonable margin of spare capacity to meet any eventualities, especially in these days of uncertainty when further demands for increased production may be forthcoming.

In the case under review, the maximum number of B.R. Standard carriage underframes were required to be produced in a works where the only available

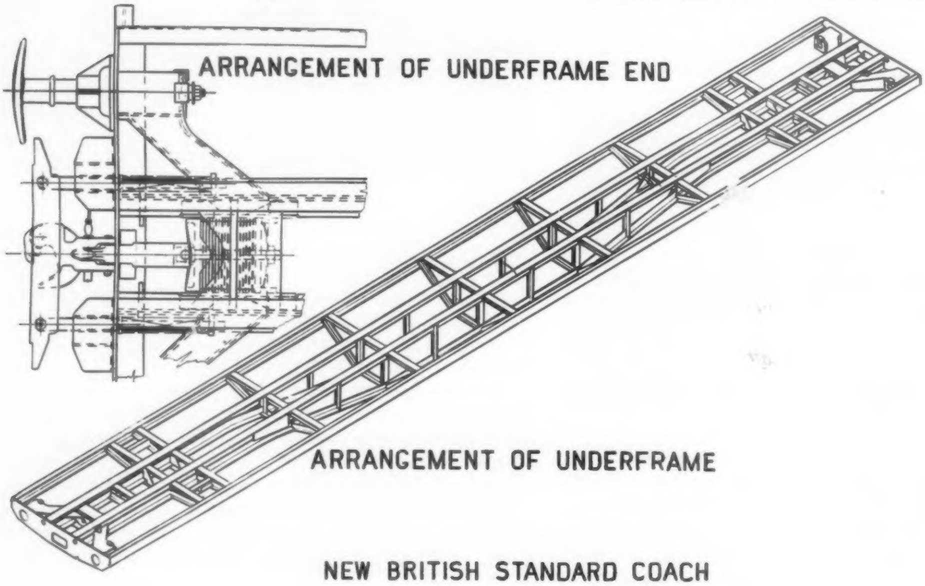

Fig. 17

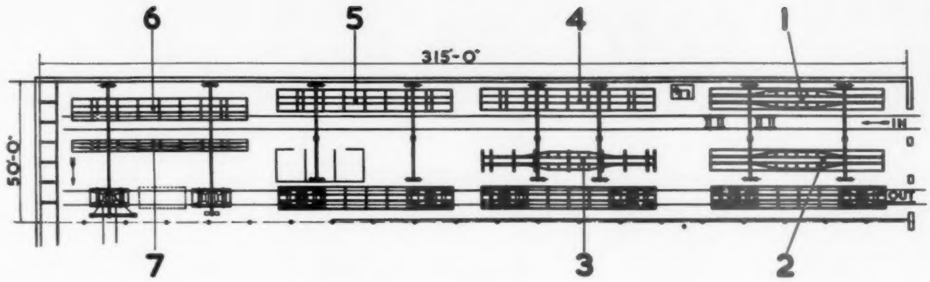

Fig. 18

shop was 315′ 0″ x 50′ 0″, thus having a floor area of 15,750 sq. ft. This only allowed seven operational positions, but study of the length and size of welds and methods of positioning to give the greatest accessibility revealed that it should be possible to produce 10 underframes per 44-hour week.

To facilitate this it was decided that, for production purposes, the structure should be broken down into three main sub-assemblies, as follows:—

A. The two longitudinals of the centre girder
B. The four headstock abutments
C. The two headstock assemblies complete

A plan of the shop concerned is illustrated in Fig. 18. The material enters at the right hand end, and is assembled in a number of progressive stages through the length of the building.

The two longitudinal members, A, after being assembled and tack welded on fixtures 1 and 2, are finished, welded at 3, and moved to 4 and 5 where they and other underframe members are assembled and partially welded. The assembled structure is then moved to 6 and 7 for finished welding, after which it is lifted on to bogies, and passes through further progressive stages, for fitting of details and painting, before leaving the shop at a point at the right hand end adjacent to where the material entered.

To avoid waste of welding time the fixture for sub-assemblies A was made in duplicate, one for assembling, one for welding, carried out alternately, and each equipped with overhead lifting appliances for positioning, making each operation self-contained. Manipulators were considered for these operations, but were rejected due to the time [illegible]tor in loading and unloading and the cost of construction.

Sub-Assembly A consists of:—

1 British Standard Tee 6″ x 6′ x $\frac{1}{2}$″ termed the Top Longitudinal.

1 British Standard Angle 5″ x [illegible] x $\frac{1}{2}$″ termed the Bottom Longitudinal.

The bottom longitudinal is designed to run parallel with the top longitudinal for a distance of 15′ 0″, and then inclines to form the tie of a Queen-post truss. A stiffening angle, 6″ x 4″ x $\frac{9}{16}$″ is welded to that portion of the longitudinals running parallel with each other, so that when completed, a cross sectional view of this portion of the structure appears like a rolled steel joist, as shown in Fig. 19.

An important feature in the design is that a gap of $\frac{1}{4}$″ is allowed between the edges of the flanges of the assembled longitudinals parallel with each other to enable a welded joint to be made.

Welding Operation of Sub-Assembly A

The actual welding operation is to butt-weld the flanges of the top and bottom longitudinals, thus filling in the $\frac{1}{4}$″ gap, the stiffening angle acting as a backing strip. A $\frac{1}{4}$″ fillet weld is then deposited along the upper and lower edges of the stiffening angle, attaching it to the longitudinals. The sub-assembly is completed by welding the auxiliary members in position.

Fixture for Welding Sub-Assembly A

The fixture for such a fabrication must be of rigid construction. In this case it is built of 6″ x $3\frac{1}{2}$″ channel as shown in Fig. 20 and the supports grouted in the ground. The locating stops are machined and the clamping devices are strong enough to overcome the stiffness of the component members of the structure, and also to rectify any slight distortion in the rolled steel sections as received from the mills. Each fixture is designed to take two structures, one right and one left hand, as will be clear from Fig. 21. Incidentally, all the fixtures for this class of work are designed with movable locating stops and clamps to suit the varying lengths of British Railway standard underframes.

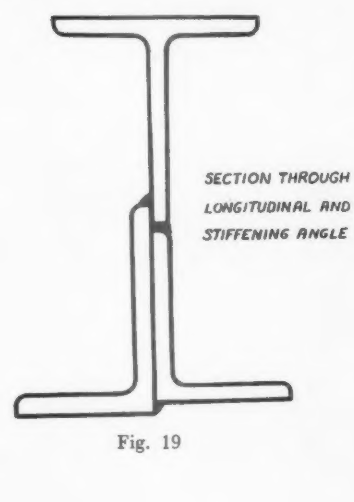

Fig. 19

Manufacturing Process of Sub-Assembly A

As previously explained the finished underframe is required to have an upward camber of $\frac{1}{2}'' \pm \frac{1}{8}''$ at the centre. The central longitudinal trussed members thus have to be constructed with this camber. In the early stages of production it was found that the long continuous welds between the top and bottom longitudinals at each end of the assembly tended to induce curvature into the structure, but to too great an extent. The stops in the jigs were therefore arranged so that when the top

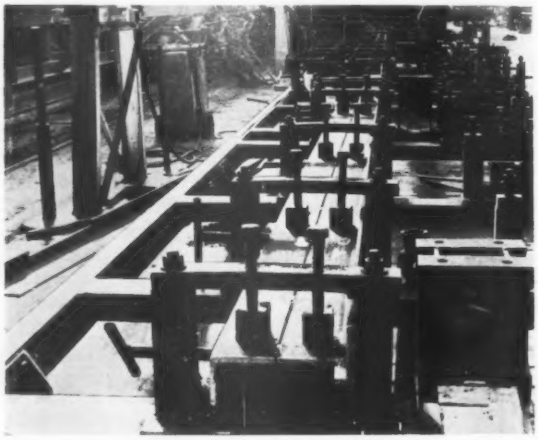

Fig. 20

longitudinal is clamped in place it has a slight reverse camber at the ends.

It is the practice first to load the jig with all members but the stiffening angles, clamp them into position and tack-weld them. The stiffening angles are then fitted and tack-welded. The tack-welding is sufficient to enable the assembly to be lifted out of the jig and transferred to the next stage for finish-welding.

Completion of Welding, Sub-Assembly A

No jig is used for this process, but the structure is placed on the fixed steel trestles which may be seen in Fig. 22, and turned by means of overhead lifting equipment, wedge blocks being used to prop the structure in intermediate positions so that the angle is such as to allow all welds to be made " down hand ". This completed, the two principals of the centre girder are ready for the final assembly.

The Headstock Abutments: General Design, Sub-Assembly B

The buffer abutment and headstock assembly is shown in Fig. 23. Each buffer abutment consists of four $\frac{1}{2}''$ plates, suitably bent, which, when assembled, form a box section, the edge of the top and bottom plates running parallel with the longitudinal members of the main frame to which it is attached in the final assembly. The buffer end of the structure is so strengthened by additional plates as to form a complete box unit.

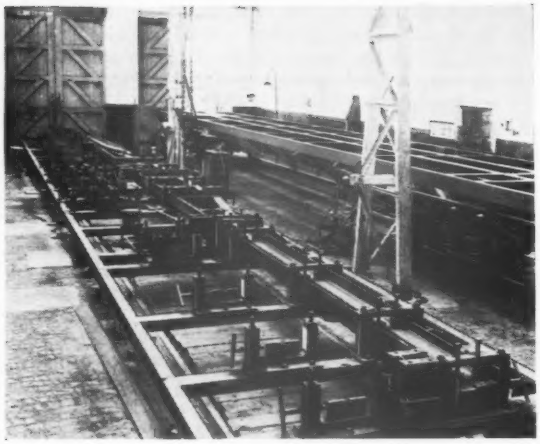

Fig. 21

The buffer back plate is machined to take the square head of the washer, through which the buffer stem passes, thus permitting limited freedom for lateral movement of the buffer when the vehicle is on a curve.

Fixture for Welding Sub-Assembly B

The jig for welding this fabrication is mounted on a positioner and designed to hold two abutments, one right hand and one left hand, as may be seen in

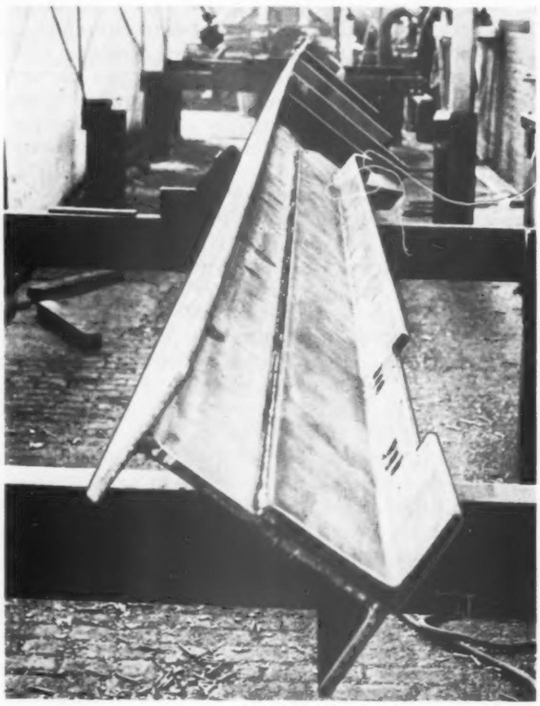

Fig. 22

Fig. 23

Fig. 24. To facilitate assembling and give accessibility for welding, the detail is jigged upside down. Two lengths of channel, made to represent the longitudinals of the finished underframe, are attached to the centre of the base plate and, to these, protruding arms, constructed from plate, are welded, having locating strips, dimensioned so as to correspond to the internal dimension of the abutments. The top plate has three small rectangular holes to facilitate clamping the component details in position. The buffer back plate is located by means of a removable jig, made to fit the square hole in the plate and positioned by an angle mounted on the base.

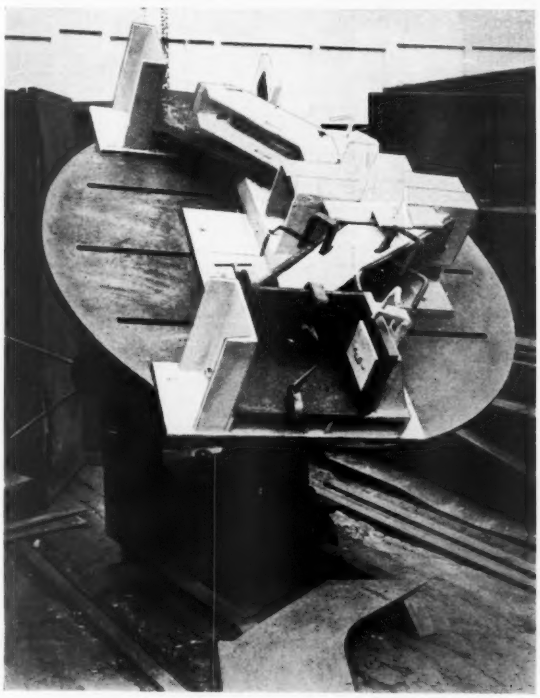

Fig. 24

Manufacturing Process, Sub-Assembly B

The order of assembly is as follows. First the top plate is placed in the bottom of the fixture, followed by the buffer strengthening plate, using one of the small rectangular holes when clamping; then the two side plates, using the two remaining rectangular holes for clamping purposes. The removable jig plate is then passed through the rectangular hole in the buffer back plate and secured. The partly assembled structure is then tack-welded to permit removal of the clamps so that the bottom plate may be inserted when the welding operation is completed. To release the finished detail, after completion, the channel representing the headstock plate and the jig plate are removed and, by gently prising, the abutment at the longitudinal position is easily detached from the fixture.

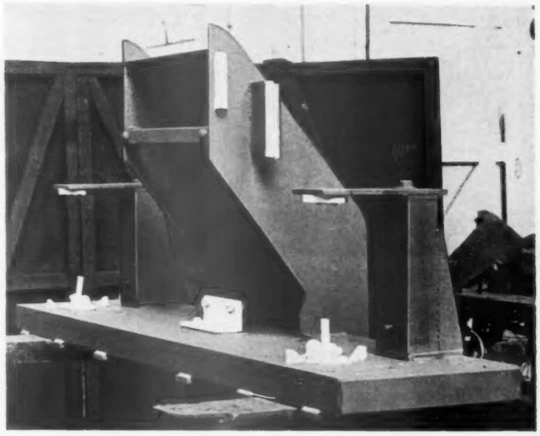

Fig. 25

The Headstock Assembly Complete: Sub-Assembly C

The complete headstock assembly comprises the headstock plate, the two abutments and the headstock strengthening plate.

Fixture for Welding Sub-Assembly C

Fig. 25 shows the fixture for this sub-assembly. It is mounted on a platform and has a base plate to which are welded four positioning stops, two at either end, for locating the headstock plate. Between each pair of stops is fitted an adjustable sliding bolt, which locks the headstock abutments in position. The centre of the fixture represents the centre longitudinal members of the underframe, the lugs on each side corresponding to the flanges. The small columns on each side of the centre structure carry jigs for correcting the vertical alignment of the headstock abutments. The headstock strengthening plate is held by the small angle in the centre of the fixture.

Manufacturing Process of Sub-Assembly C

To load the fixture, the headstock plate is placed on the base plate so that the large hole at each end

of it, through which the buffers eventually pass, is located by the stops on either side of the locking bolts, as shown in Fig. 26. The abutments are then set against the lugs on the central portion of the jig at the upper end and locked by the bolts at the lower end. They are located at a third point by means of the plates on the arms mounted on the columns on either side, as shown in Fig. 27. Finally, the stiffening plate is bolted to the central angle bracket and the assembly is ready for welding.

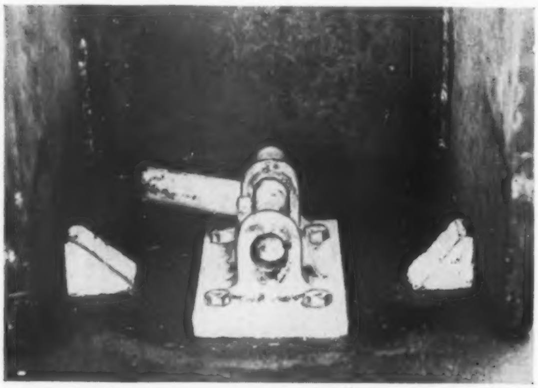

Fig. 26

Fixture for Final Assembly

The fixture for the final assembly is shown in Fig. 28. It must of necessity be a heavy structure, not only on account of the weight of the work, but also to overcome the resistance of the combined fabricated members of the sub-assemblies and any distortion which may have occurred during their manufacture. It is built of rolled steel joists, channels and tees, well braced to ensure absolute rigidity, for a tolerance of $\pm \frac{1}{16}''$ only is allowed in width throughout the entire length of the underframe.

To simplify assembly and provide the greatest accessibility for welding, it is designed to allow the structure to be built in the inverted position, providing for the correct camber of $\frac{1}{2}''$.

The locating and clamping devices must again be of sturdy construction, and since the only safe procedure, when positioning rolled steel sections, is to locate from the outer face of the member, special clamping arrangements are necessary to allow sufficient clearance to accommodate the flanges.

In this particular instance, locating pins are used (see Fig. 29) and these are fitted with tapered cotters so that the members are held firmly against the locating stops. When released the bolt has a free movement of approximately 7″. In the case of the inside members, the body of the clamp is pivoted and can be locked in position before the locating pin comes into operation. This method of clamping has proved very effective, quick in action, and simple to

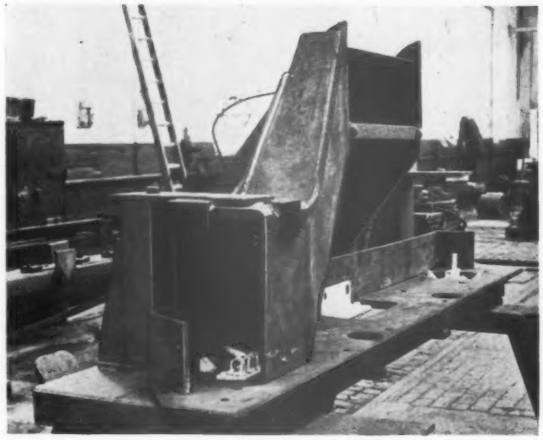

Fig. 27

operate. Another feature of this particular fixture is the adoption of eight quick acting screw jacks, four at each end of the fixture, to assist in position-

Fig. 28

Fig. 29

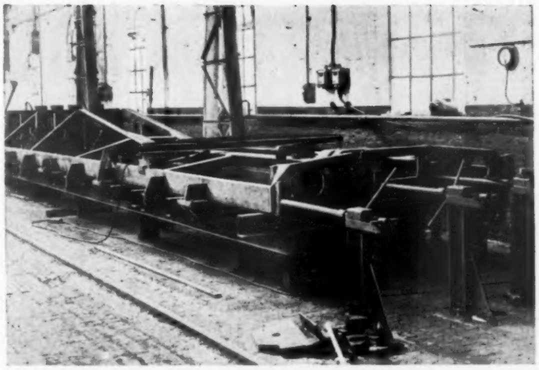

Fig. 30

ing the complete headstock assembly (see Fig. 30).

Fig. 31 shows the clamps for holding the cantilever outriggers and auxiliary members. These are designed so as not to interfere with the underframe being lifted out of the fixture.

Method of Assembly and Welding

First, the two longitudinal sub-assemblies of the centre girder are placed in position against the inner supports of the fixture, followed by the two outer channels (solebars) as shown in Fig. 32 and the four aligned by locating stops, situated midway along the fixture.

The transverse members of the centre girder are then fitted, followed by the top and bottom cantilever outriggers, and lastly the complete headstock assemblies. To rectify any possible distortion which may have occurred during the welding of the sub-assemblies or any irregularities in the rolled steel sections, the cantilever outriggers and auxiliary members are cut so as to allow for grinding during fitting, thus ensuring good butt joints.

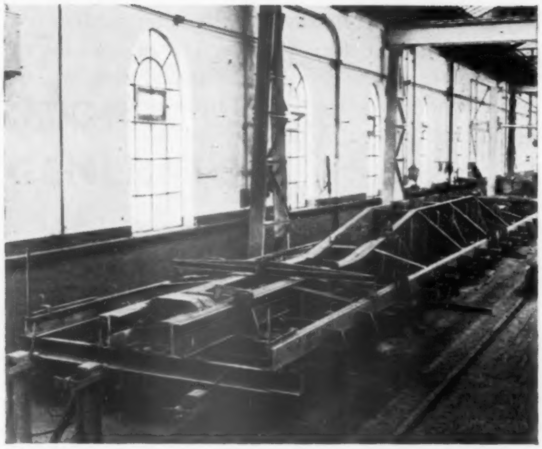

Fig. 32

The welding procedure is planned to begin from the centre of the centre girder and work outwards, and from the ends of the structure working inwards. The entire cross section of the contacting ends of all the auxiliary members is welded, resulting in a series of short runs. Only downhand welds are made in the fixture and, when these are completed, the structure is moved to the final welding stage.

Here, it is stood on its side by means of overhead lifting equipment as shown in Fig. 33, and all possible downhand welds are carried out. The structure is then reversed and the same procedure followed. The underframe is then mounted on its bogies and the top surface welds completed.

Fig. 34 shows a completed carriage underframe. It is of interest to note that, despite the fact that there are some 950 ft. of welding in the structure, the size of fillet varying from $\frac{3}{16}$" to $\frac{3}{8}$", it is almost unknown for the finished frame to require

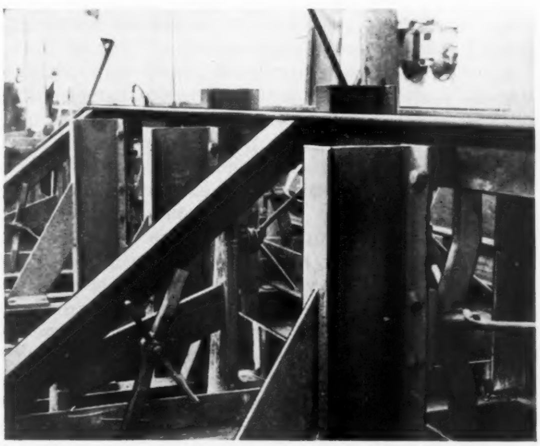

Fig. 31

Fig. 33

any correction for distortion or misalignment. This, coupled with the fact that the production cost of this underframe, as produced from the shop lay-out under review, is as low as any in the country, speaks well for the jigs and fixtures employed.

Acknowledgments

In conclusion, I should like to thank the Railway Executive, and in particular Mr. F. Munns, Carriage and Wagon Engineer, Southern Region, and Mr. L. I. Sanders, Carriage and Wagon Works Manager, Ashford, for the facilities granted, and all those concerned in the production and design of the rolling stock dealt with, without which the preparation of this Paper would have been impossible.

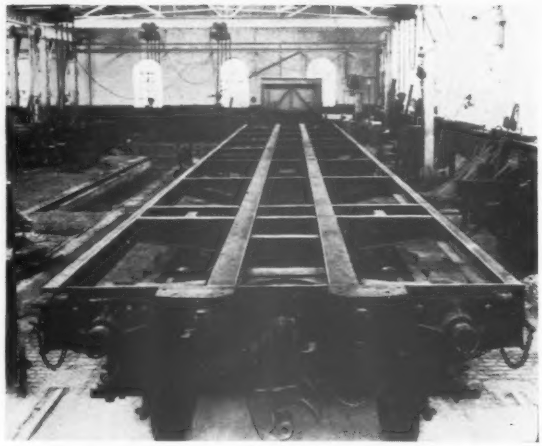

Fig. 34

PRODUCTIVITY STUDY COURSES

Following upon the Summer Course on Work Study, held this year at the new Birmingham University Institute for Engineering Production, a series of short residential courses on the introduction and use of productivity study methods in industry has now been arranged for Works Managers and senior Production Engineers.

The courses each run for two weeks and may be attended separately or in sequence up to a total of six weeks. Each course will provide an opportunity for specialists in the work study, process development and operational research, and other productivity study fields, to exchange experience and to discuss practical application problems with industrial executives responsible for the introduction and development of productivity improvement work in their own companies.

The year's programme will end with a five-day conference to discuss the problems of applying scientific and industrial research results in raising industrial productivity.

The Institute for Engineering Production, Birmingham.

The inclusive charge for the normal two weeks residential course is £30 per member. Full particulars may be obtained from the Senior Course Secretary, The Institute for Engineering Production, "Southfield", 16, Norfolk Road, Edgbaston, Birmingham, 15. (Tel: Edgbaston 0390.)

FELLOWSHIPS FOR STUDY AND TRAVEL IN AMERICA

The Commonwealth Fund, New York, announces that twenty Fellowships for advanced study and travel in the United States are offered in 1954 to men and women who are British subjects and degree graduates of a university in the United Kingdom of Great Britain and Northern Ireland. The Fellowships are tenable for a period of twelve months, but may be extended, at the discretion of the Directors, for a further period of nine months.

Candidates are required to show a record of marked ability during their university careers, and of proficiency in some recognised branch of learning, art, or the professions. Experience in research and in post-graduate study constitutes a valuable (but not indispensable) qualification for appointment. It is hoped that among the applicants there will be some engaged in industry or in professional work who can secure leave of absence for a year of study in the United States in some scientific, technical or other field of interest and value to them.

Candidates, who must be available for interview in London in March, 1954, may be married or single, but should be over 23 and under 32 years of age on 1st September of the year of award. Full particulars regarding these Fellowships may be obtained from The Warden, Harkness House, 35, Portman Square, London, W.1.

THE MANUFACTURE OF A LARGE WATERWHEEL GENERATOR

by R. H. S. TURNER, M.A. (Cantab), M.I.Prod.E.

Presented to the Manchester Section of the Institution on 26th January, 1953.

Mr. Turner was educated at King's College School, Wimbledon, and St. John's College, Cambridge, and was a college apprentice at Metropolitan-Vickers Electrical Company Limited during 1930/32.

Following appointments in the Erection, Instrument and Meter, and Plant Departments, he became Superintendent of the Plant Department in 1948 and was appointed Assistant Works Manager, Main Works, Trafford Park, in 1952.

Mr. Turner was President of the Manchester Section of the Institution of Production Engineers during the period 1951/53.

Mr. R. H. S. Turner

THIS Paper deals with the manufacture of a particular waterwheel generator which is fairly typical of present-day practice in the design of large, slow speed, vertical shaft, water-turbine driven A.C. generators.

The main features of the machine are briefly discussed, with special reference to those design features which are influenced by considerations of manufacture, handling and erection on site.

Production problems associated with the construction and planning of such a large, individually-built machine are considered, prior to a detailed analysis of the processes involved in producing the larger components of the generator.

From the receipt of raw materials, manufacture is traced through the fabrication shops and the machine shops to the core-building and armature winding sections. Sub-assemblies and main assembly work lead up to the testing stage, where the machine is given full operational and overspeed runs, prior to dismantling and packing for shipment.

The machine under consideration is a 33,000 kVA waterwheel generator, (Fig. 1), operating at 11,000 volts, 50-cycles, and is one of three commissioned by the New Zealand Government.

The total weight of the generator is 330 tons, of which the rotating element, carried on a single thrust bearing of special construction, is 182 tons. The overall diameter is 34 ft. and the height approximately 29 ft.

Normal operational speed is 166.7 r.p.m., making it a 36-pole machine, but water-turbine governing limitations necessitate a construction which will allow a safe overspeed of 410 r.p.m.

In this instance, the thrust bearing and single guide bearing are situated below the dished arms of the rotor, giving what is known as the "umbrella" type of construction.

General Construction

(a) *Stator*

The stator frame, or yoke, is built up of welded plates and is made up of four sections for ease of handling. The joints between the sections are heavily flanged and held together by bolts and dowels.

The yoke carries the stator core, consisting of silicon-alloy laminations punched in segments. Each segment is secured by half-dovetail notches in the outer corners, which engage with suitably positioned dovetail bars welded in the stator frame. The segments overlap in successive layers and in such a manner as to produce slots in which the stator windings are later embedded. To ensure tightness of the core, which is essential if vibration and damage to insulation are to be avoided, the punchings are clamped between heavy welded steel endplates secured to the frame.

The stator winding is accommodated in the core slots and is of the two-layer, diamond coil type, all coils being duplicate and interchangeable. Prior to winding, the coils are formed, insulated, impregnated and fully tested at $2\frac{1}{2}$ times the voltage they will be subject to in service.

(b) *Rotor*

The shaft forging, heavily flanged at one end for coupling to the turbine shaft, carries the thrust

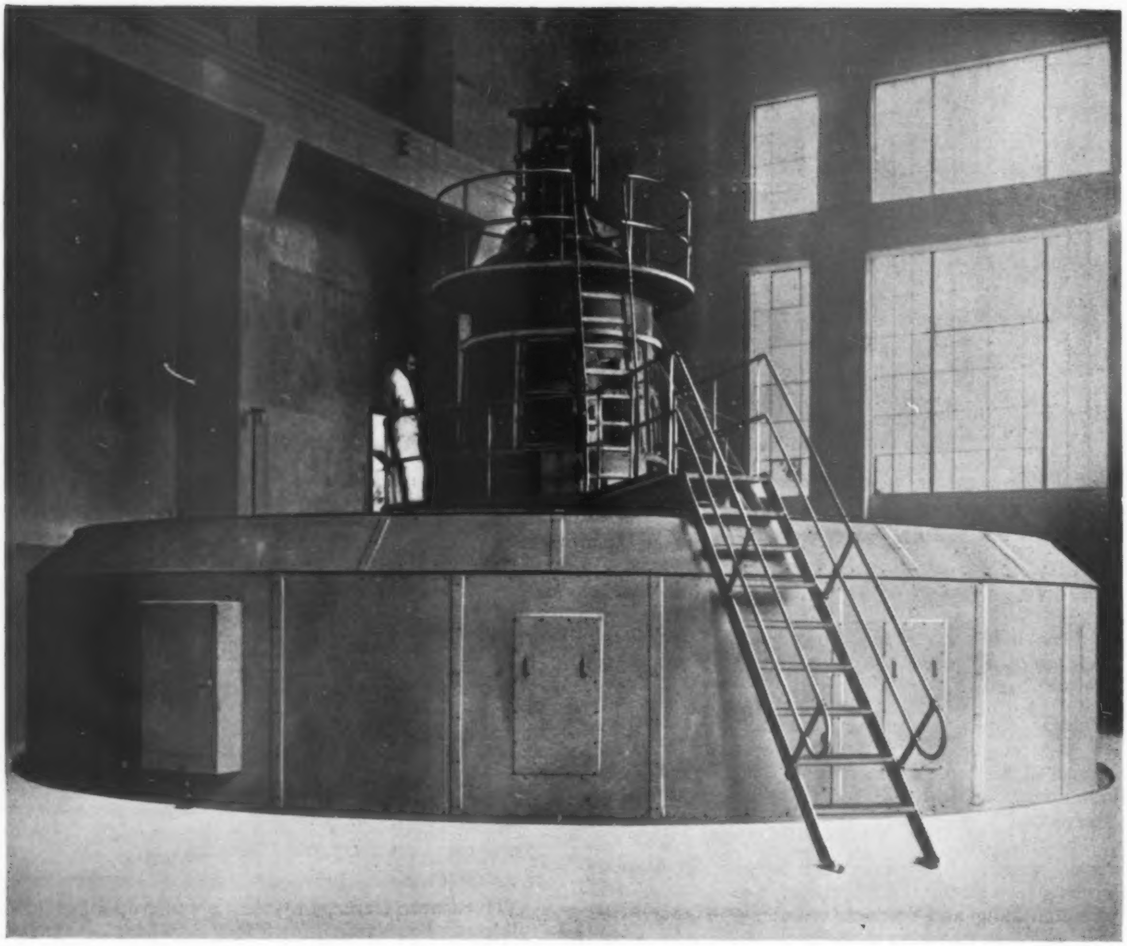

Fig. 1

bearing collar and a cast steel flanged hub, pressed and keyed in position.

Eight fabricated arms are secured to the hub by means of two clamping rings and taper shank bolts (Fig. 2). Such an arrangement permits the rotor to be lifted without its shaft and hub, thus avoiding exceptionally heavy lifts during manufacture and also reducing the crane capacity at the point of installation.

The fabricated arms carry a heavy rim of steel laminations suitably punched to produce T-slots in which the poles carrying the field coils will engage (Fig. 3). There are twelve laminations, $\frac{1}{4}$-in. thick, to the circle, and each lamination covers three pole pitches. They are overlapped in the same manner as the stator core punchings, and are compressed between heavy steel endplates by a large number of fine clearance bolts. Friction between laminations is sufficient to prevent slip even at high overspeeds. The whole rim is built on radial floating keys, so that no centrifugal forces are transmitted from the rim to the spider arms or the hub.

Poles (Fig. 4) are built of steel laminations compressed between heavy semi-circular cast steel endplates. They have T-form heads which engage with T-slots

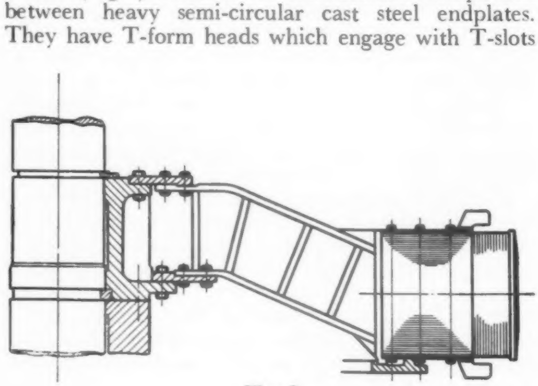

Fig. 2

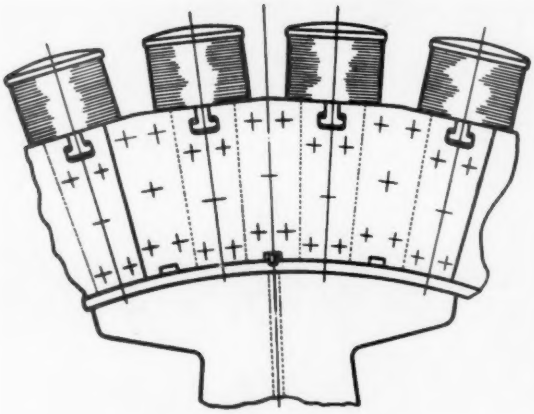

Fig. 3

Fig. 4

in the rotor rim and are secured in position by two-part taper keys.

Field coils (Fig. 5) are edge wound, with bare copper strap on formers to suit the poles, and insulated between turns with asbestos. Insulation between pole and coil is provided by flexible micanite, built up on a strong cloth backing. Coils are hot-pressed during manufacture to ensure that no shrinkage takes place in service.

(c) *Thrust and Guide Bearings*

In addition to carrying the weight of the generator rotor, the thrust bearing has to support the weight of the water-turbine runner and shaft, plus the hydraulic thrust—a total of 750 tons. Together with the single guide bearing, the thrust bearing is contained in an oil-tight housing, rigidly supported by eight deep sectioned, welded steel arms (Fig. 6). The runner disc, forming the actual bearing surface, is machined and polished to a high degree of flatness and a surface finish of four to eight micro-inches. It is bolted to the face of the thrust block.

The runner disc bears on eight white-metalled pads, arranged as segments of a circle. In order to provide a degree of flexibility in the bearing, the pads are supported on short springs, 135 springs per pad, which are located in the thrust bearing spring plate. Each spring is precompressed an amount corresponding approximately to the load which it will carry in service, and secured under compression by a bolt and washer. This precompression limits to a small amount the change in the length of the spring between " no load " and " full load " conditions, while providing sufficient flexibility to allow the bearing pads to tilt slightly at starting. This assists in the formation of an oil film between the pads and the runner disc.

The thrust bearing runs submerged in oil with special baffle arrangements to prevent the oil swirling. Oil from the bearing is circulated through coolers external to the generator.

Fig. 5

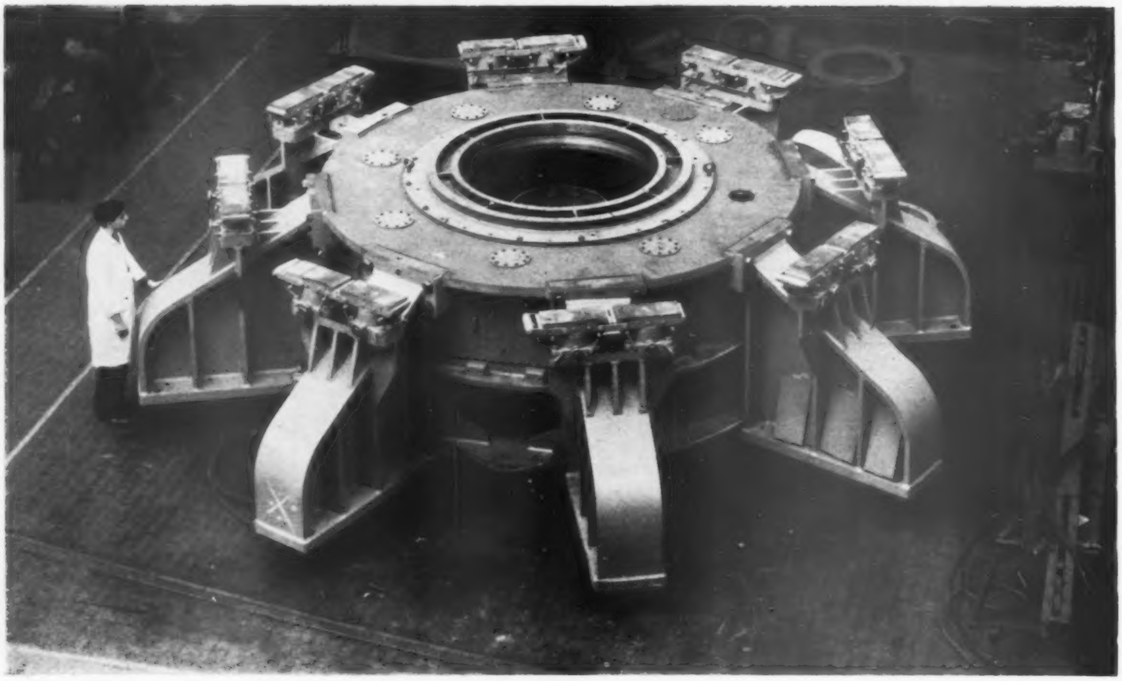

Fig 6

The guide bearing is situated immediately above the thrust bearing, the journal being formed by the upper cylindrical portion of the thrust collar. The bearing itself is a casting, lined with white metal, and made in halves for ease of assembly and dismantling. Oil is supplied from the main thrust bearing, both from the main oiling system and centrifugally through ducts in the thrust collar.

(d) *Braking System*

Eight pairs of hydraulic air operated brake cylinders are mounted on the bearing bracket arms. These operate on a removable brake track mounted on the rotor arms. The brakes are intended to be applied at half speed when the generator is being shut down, not only to reduce the time taken to come to rest, but also, by increasing the rate of retardation at low speeds, to reduce the amount of wear that can take place in the thrust bearing during the last fraction of a revolution after the oil film is broken.

The brakes may also be used as jacks to raise the rotor, so that the bearing surfaces may be flooded with oil when starting up the generator. This system also allows the rotor to be lifted in order that the bearing pads may be removed for inspection or repair. During manufacture the brakes are tested at 2,000 lbs. per sq. in. pressure.

(e) *Auxiliary Equipment*

A main exciter and a pilot exciter, which energise the field windings, are vertically mounted on the end of the generator shaft. They are so disposed that their commutators are adjacent to the main generator slip rings. This arrangement allows for accessibility and ease of maintenance. A platform is provided at the base of the main exciter.

The governor generator (Fig. 7), supplying power to the electrically-driven turbine governor, is mounted immediately above the guide bearing. The permanent magnet revolving field is carried by the main generator shaft, the stator being housed in the top bracket.

(f) *Handling*

Since waterwheel generators are frequently installed in mountainous sites with limited access, consideration has to be given at all stages to a construction which reduces the number of large or heavy pieces to a minimum. In the case of this particular machine, the generator shaft which, of necessity, must be in one piece, is the heaviest lift, and weighs 20

Fig. 7

tons. All other parts are well below this figure, and are dimensionally of such a size that they can be handled by normal road transport. It is a striking fact that an electrical generator weighing 330 tons complete can be broken down into such relatively small parts for transport. This feature is also, of course, of paramount importance in the actual manufacture of the machine, in that heavy crane lifts are minimised, and machine tools required, although large, are not necessarily special. Much work can also be done in parallel, thus reducing total manufacturing time.

Production Arangements

The production of a machine of this size presents many problems to the Production Engineer. Manufacturing information issued by the drawing office, covering the main machine, runs to over 750 pages; whilst an equal number may be issued covering orders for exciters, pumps, lubrication system, control gear, etc. Some 250 drawings, covering approximately 3,000 different items, are involved, ranging from large fabrications and forgings to small nuts and bolts. Machine tools required range from a 28 ft. vertical boring mill to the smallest capstan lathe, and are, in general, standard machines.

Such a diversity in the size of components necessitates the most careful planning to ensure that items are ready as and when required. The larger items take up valuable floor space and must neither be prepared too soon, nor held up for detail parts, if serious interference with the flow of work through the shops is to be avoided. In many instances, because of the special sizes, quantities or qualities of material involved, orders have to be placed well in advance and are, in fact, ordered before the final drawings are produced. As an example, 36 tons of silicon alloy sheet steel are required for the stator punchings, 32 tons for the pole punchings, and 85 tons for the rotor rim punchings. Sixty tons of steel plate in varying thicknesses are needed for fabrications, while 20 tons of copper strap are required for coils. In all these cases, suppliers' estimated delivery times must be allowed for in addition to manufacturing and process times in the shops.

The purchasing of the necessary raw materials is undertaken by the Purchasing Agent to dates supplied by the Production Department and specifications issued by the Drawing Office. The dating is effected in line with a production programme chart showing at which stage manufacture of each major item is to commence in order to achieve the final delivery date agreed with the customer. This chart is marked up regularly to show progress, copies being supplied to the foremen of departments concerned. It has been found by experience on large work of this nature, that the date for commencement of operations is of vital importance. Since many of the operations are of a lengthy character, completion dates cannot be kept unless the work is put in hand at the right time. Emphasis is therefore continually made in the machine shops on starting operations strictly in line with the chart issued. No individual variations in timing are countenanced, but the whole programme may be re-dated by the Production Engineer should, for instance, some vital material supply be delayed.

It will readily be understood that this type of machine is designed to suit conditions at the site of the hydro-electric station and that therefore there is practically no opportunity to standardise any of the major parts. Each component, therefore, has its individual problems of handling, machining and erecting. Special tooling is naturally at a minimum, but for this particular machine some 120 tools, templates, jigs, gauges, etc., were made in order to assist production and to ensure accuracy in the assembly of mating parts. The majority of machining is done to marking-out, and is subjected to a rigorous inspection both during machining and on completion of each component.

Manufacture of Major Items

(a) *The Stator Frame*

Fabricated in quarters, the stator frame, commonly called the yoke, uses 35 tons of mild steel plate and consists of 37 different items, 21 of which are welded together. The joint flanges are premachined and drilled prior to welding, and the core bars are rough machined, drilled and drawn to their dovetail shape before being welded in position. Some 16 burning templates and 4 special spacing gauges for positioning the core bars are required in the fabrication shops.

Joint flanges are bolted together in pairs with $\frac{1}{8}''$ spacing liners between and welded into position in the fabricated quarters, quarter by quarter, until a full circle is obtained. At this stage, the dovetail core bars, which require no further machining, are welded into positions correctly spaced both as to chord and radius. A telescopic stand carrying an adjustable micrometer head is set to the centre of the yoke, the micrometer head being set to the required radius of the inside of the core bars. The core bars at the yoke joints, which are in fact in halves vertically, are positioned first, being set true with the aid of a square, the micrometer head and a chordal gauge to pitch a quarter circle, which is the equivalent of an 18 bar pitch. Having established the position of the joint bars, the mid-quarter bars, 9 pitches apart, are set and welded in using similar methods. The intermediate pitches are then proceeded with until all the core bars are welded in, the final accuracy achieved overall being $\pm$ .015".

The yoke, having been split into quarters after an inspection check, is now ready for machining. This is reduced to a minimum by the barring method described and consists of the planing of the location pads on the top and bottom faces on a 10 ft. planer to datum lines marked in the fabrication shop, and a certain amount of drilling under 10 ft. radial arm drills. After the usual inspection check, the quarters proceed to the core building shop which is adjacent to the heavy machine shop.

Still working in quarters, the bottom endplate segments are bolted to the yoke and the core laminations built on the dovetail core bars. Each successive layer of punchings is overlapped, using half punchings at the ends of each quarter in such a way that a true face is built up at the joints. As building proceeds,

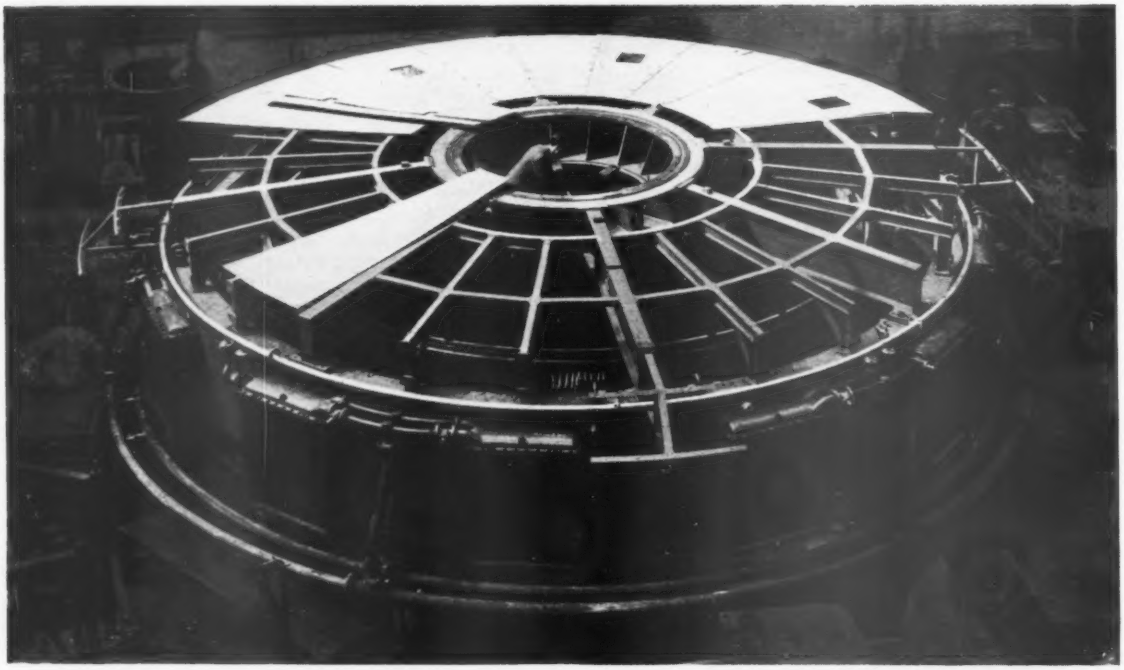

Fig. 8

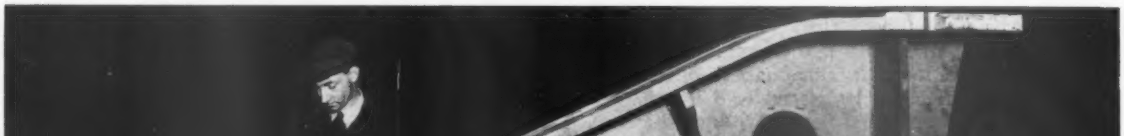

Fig. 9

the core is pressed every 10" in depth by hand or hydraulic clamps until the correct consolidated core length is obtained. The top endplate segments are fitted and the core finally tightened up between the top and bottom endplates, using torque spanners to avoid overstressing or under-tightening the bolts.

Having checked the core slots for accuracy of size and removed any projections, either in the slots or at the joint faces, the yoke is assembled in a full circle but without the spacers between the joint flanges. This allows the core laminations to butt and ensures a sound joint without distorting the stator frame. The bore is checked for size and concentricity and the joint plates drilled and reamed for dowels in radial and axial positions.

At this stage it is convenient to check the assembly of the top bracket which will support the exciter yokes and platforms prior to splitting the yoke again into quarters preparatory to winding (Fig. 8.)

The stator coils, which have been in process of manufacture in parallel with the frame, are of the two-layer, diamond coil type, vacuum gum-impregnated, and are assembled directly into the open slots of the core. Coil joints are clipped and soldered, insulated to the required standard and the whole winding wedged, connected and braced before being finally pressure tested. The coils passing over the joints are omitted if the machine is not to be tested in the works or if the complete stator is too heavy or awkward to lift conveniently, in which case they are wound in when the stator is assembled on test or on site.

(b) *The Spider Hub*

The cast steel rotor hub, weighing 12 tons, is a straightforward machining item on a vertical boring machine. Dimensions have to be maintained to fine limits to provide the necessary press fits on the shaft and the correct spider arm locations. It is normal practice to machine the hub before the shaft in order to avoid risk of scrapping, either due to an oversize or taper bore in the hub. The casting is pickled and crack detected before any machining work is done, any welding repairs being carried out to the satisfaction of the Research and Inspection Departments.

(c) *The Spider Arms*

The eight arms (one of which is shown in Fig.9) are fabricated from 26 tons of mild steel plate and are made up of 27 flame cut items. They present many machining problems both in setting and measuring. They are set up on a 28 ft. vertical boring mill in equally spaced and correct radial positions using temporarily welded brackets and a variety of setting blocks to secure adequate clamping. Some idea of this task can be visualised from the dimensions of the set-up: inside diameter 57"; outside diameter 257"; and overall height 66". The arms are bored and faced for hub location and the outside diameter turned and faced to provide an accurate location for the laminated rotor rim. The accurate measurement of the large diameters

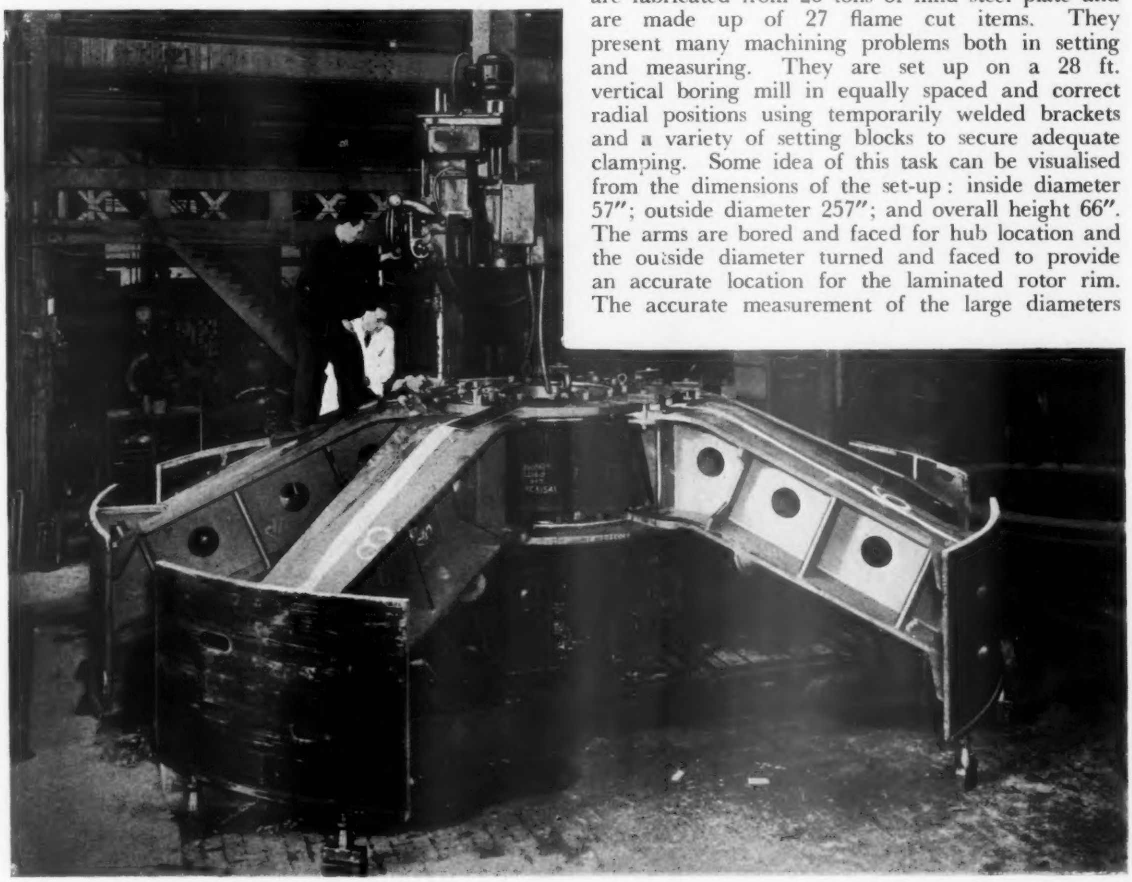

Fig. 10

divided into eight separate parts calls for special care. A post or bush set true in the centre of the mill table is used in conjunction with a straight edge clamped to one vertical column set to a pre-determined radius. All setting and measuring is done with the close cooperation of the Inspection Department, as an error at this stage would cause serious trouble when assembling and building the rotor.

After machining the brake-track seating, the arms are marked out for the hub securing holes and individually drilled under a large radial arm drilling machine, leaving an allowance in for final taper reaming after assembly to the hub. By this time the two clamping rings have been machined and rough drilled. They are clamped to the hub with temporary bolts. This sub-assembly is then mounted in such a way that the spider arms can be offered up to it and also clamped to the rings by temporary bolts. The whole assembly is now lifted to a 10 ft. radial arm drill where it is inspected to ensure that there has been no relative movement of hub, rings and arms, before taper reaming is carried out. Each hole is reamed (Fig. 10) to suit a $2\frac{3}{16}''$ taper shank bolt, and each hole is fitted with its bolt before proceeding with a further hole. The temporary bolts are replaced as the work proceeds.

Having completed one side, the whole assembly has to be turned over, involving most exacting slinging and crane work, to enable the reverse side to be fitted with its taper bolts (Figs. 11 and 12).

The vertical keyways in the arms are now marked out and machined on a large horizontal boring mill, while various detail drilling operations are carried out so far as possible at the same time, using a portable drill. This completes the rotor spider which is passed to the core building shop for assembly of the laminated rotor rim.

(d) *The Rotor Assembly*

The completed rotor spider is set up on suitable packings so that the brake-track segments, which act also as a bottom endplate, can be secured to the lower face of the arms. Packings are placed under the brake-track segments to prevent undue distortion during pressing operations, and the lower endplate segments positioned. The driving centre keys are secured to the arms and the rim bolts assembled, the inner row being secured to the brake-track. Several layers of punchings are now built up, conforming to a definite sequence in order to stagger the joints between layers. After a check to ensure that the punchings are building correctly, the side keys are fitted against the centre driving keys and pole slot building bars inserted in the pole slots, so that as building proceeds, pole slots are produced having smooth and regular faces. The rim is pressed every six or eight inches and final tightening is carried out between the endplate segments to a pre-determined figure. Some 480

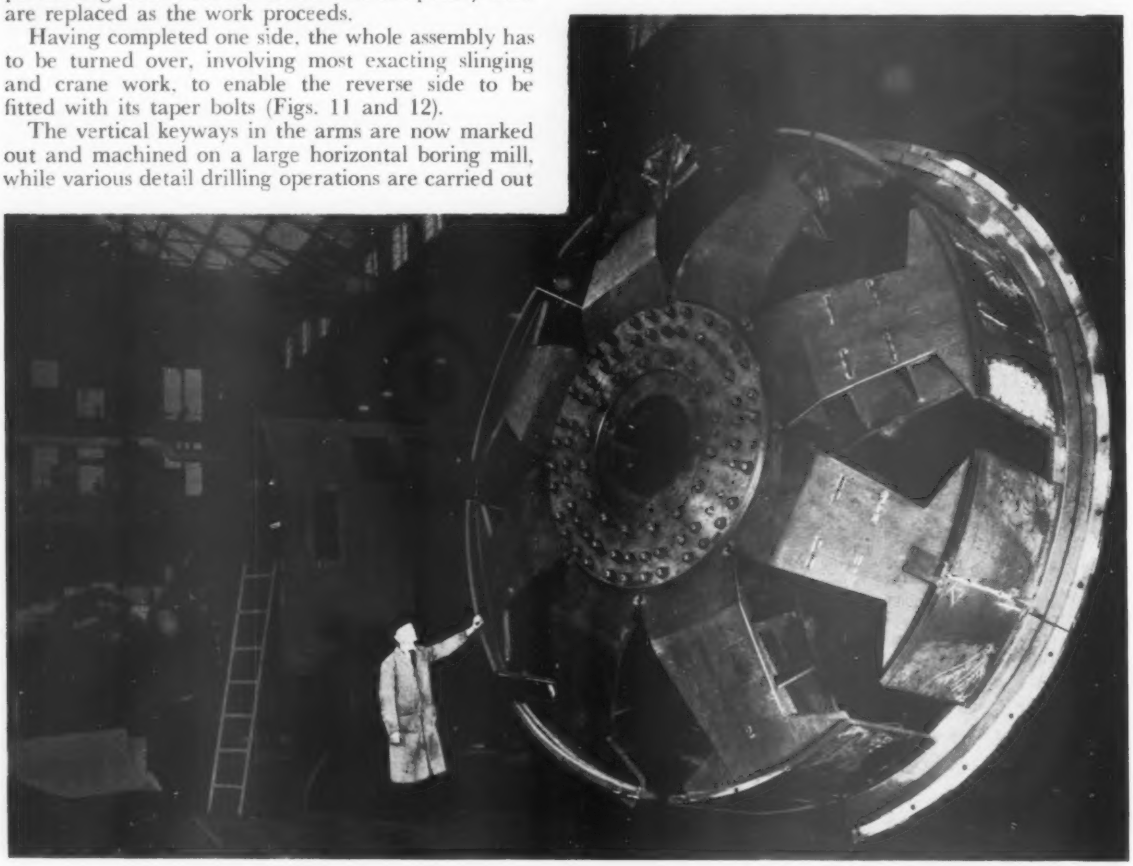

Fig. 11

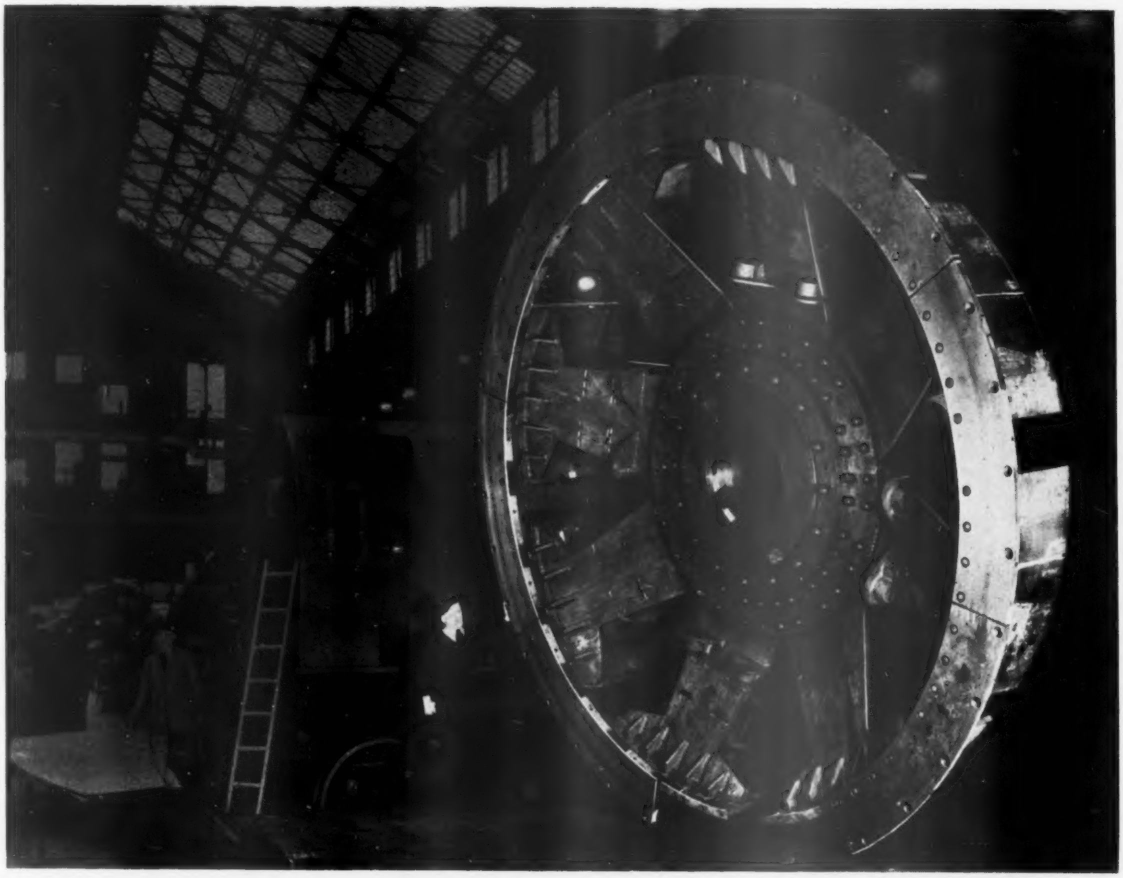

Fig. 12

core bolts have to be pulled down, ensuring that the friction between punching layers will be sufficient to avoid slip even at run-away speeds, but without overstressing any of the bolts.

The temporary bolts holding the three parts of the driving keys are removed and the side keys driven home. The pole slot building bars are taken out, poles and coils assembled into the slots and the taper retaining keys fitted to position. Blower segments, damper winding connections and connections to collector are fitted, completing the rotor for its assembly on test.

(e) *The Main Shaft*

This forging, weighing 15 tons, is handled in a large centre lathe capable of swinging its 45″ flange and taking 17 ft. between centres. Accurate machining is necessary to ensure correct interference fits with mating parts, and the positioning of keyways in relation to the coupling face is of great importance.

The shaft is first rough turned, leaving a nominal allowance of approximately $\frac{1}{10}$″ on all dimensions. Two keyways for the spider hub, 6″ wide, $1\frac{1}{2}$″ deep and 60″ long, are rough milled and the coupling bolt holes rough drilled. The removal of such a volume of metal causes slight distortion of the shaft, which is corrected during the later finish turning operations. Final milling of the keyway and detail drilling operations complete the shaft, except for the reaming of the coupling holes.

At this stage, the shaft is bolted to the turbine extension shaft, which is provided for the purpose by the turbine maker, by means of temporary bolts through the rough drilled coupling holes. The combined shafts are mounted in the lathe and very careful setting of both shafts for alignment and for concentricity is carried out. By means of special boring gear developed for the job, each coupling hole is fine bored to $3\frac{1}{2}$″ diameter and close tolerance bolts fitted. Each hole in turn has its temporary bolt removed, and the permanent fitted bolt inserted before proceeding to the next hole. Extreme care is taken to ensure a first-class finish in the coupling bolt holes and each bolt is stamped to its corresponding hole.

(f) *Thrust Block*

A steel casting weighing 11 tons, 72″ diameter and 46″ high, is used for the thrust block. Here again, accurate machining is of the utmost importance as

Fig. 13

the block is seated on the generator shaft and carries both the thrust bearing runner disc and the guide bearing sleeve. Turning and boring are carried out in two stages on a vertical boring mill. At the first stage, the block is rough turned all over and the guide bearing seating and runner disc face are finish machined, drilled and tapped.

After assembly of the guide bearing sleeve, which is shrunk on to the block, and the runner disc, (both forged steel items which have been previously machined), drilling for oil holes, dowels, etc., is carried out, followed by planing the two keyways. The assembly is then returned to the boring mill for the second stage, final machining. The bore, the guide bearing journal and the thrust face are all machined at one setting in order to guarantee concentricity and truth. Finally the guide bearing journal is polished, but the runner disc is removed from the thrust block and independently polished on another mill. (Fig. 13).

(g) *The Runner Disc*

The running face of the thrust bearing consists of a steel disc 72″ in diameter, 4½″ thick and 34″ bore. After rough machining and drilling, the disc is secured to the thrust block and finish turned in position as already described. It is then removed from the block and truly mounted on an accurate vertical boring mill, where a light cut of a few thousandths of an inch is taken off the running face, obtaining the best possible tooled finish. The tool box is then replaced by an oscillating, independently driven head carrying a cast-iron lap charged with lapping compound and flexibly mounted. The lap is of such a diameter that the annular face of the disc is covered at any position of the head during oscillation. Surface speeds of 50 ft. to 80 ft. per minute and approximately 16 oscillations per minute are used.

The lap is cleaned and recharged and the work piece washed down with paraffin after every three or four hours' working, the grit size being reduced as the tool marks disappear. A lead faced lap and fine grit is used to obtain a smooth and polished finish and this is followed by a final polish with a high speed mop.

Measurement of the surface finish is achieved by using plastic replicas in conjunction with a Talysurf measuring machine. Dimensional accuracy is checked by a 1/10 thousandth indicator clock and a master straight edge. Details of the lapping operation are as follows:-

Cast Iron lap	180 grit paste	25 hrs
,, ,, ,,	320 ,, ,,	30 ,,
Lead Face ,,	320 ,, ,,	8 ,,
,, ,, ,,	500 ,, ,,	8 ,,
High Speed Mop	emery soap	4 ,,

Dimensional error, radial and tangential : .0003″ max.
Surface finish : 6 micro-inches (average).

This particular disc was checked using interferometer methods, and the figures were confirmed in every respect.

The surface area of the disc is 3,170 sq. ins. The overall time of 100 hrs. for machining and lapping is, therefore, less than two minutes per sq. in. of area.

(h) *Bearing Pads (Fig. 14)*

Constructed from mild steel plate to form a circle 72½" outside diameter, 34" inside diameter, in eight segments. They are rough machined all over and various milling and drilling operations carried out before white-metalling.

In order to ensure complete adhesion between the metals, the segments are degreased and acid-treated immediately before tinning and babbitting. An extra segment is made with each batch of pads, and this segment, after receiving the same treatment as the others, is tested for adhesion by hammer and chisel and supersonically before the batch is released for further operations.

Owing to the difference in physical properties between the steel and the babbitt, extreme care has to be taken in final machining, as the removal of an excess of metal from one face would cause the other to distort. At least two cuts off each face are found necessary to produce the required accuracy. Variations in thickness and flatness do not exceed .0005", and the surface finish of the babbitt is of the highest order. No scraping is permitted and caution has to be exercised in the handling of the segments, as the slightest damage would entail many hours of rectification work.

(j) *Bearing Support Springs*

The springs are manufactured from high quality spring steel, accurately formed, with the ends ground square to the axis and to fairly close limits in length. They are assembled between the two endplates in an air-operated fixture, the air pressure being controlled to give the required degree of pre-compression. The spring is held to length by a tap-bolt through the endplates. The length over the endplates is most important and is obtained by machining in a lathe, using a suitable fixture. By this means all spring assemblies are of the same length and have identical pre-compression, thereby ensuring that they share equally the load of 750 tons imposed on them (Fig. 15).

(k) *The Bearing Housing*

This is a major fabrication (Fig. 16) consisting of 36 different items welded together and requires some 20 tons of steel plate. It contains the thrust support face, the main oil well and supports for the bottom bracket arms. All welds connected with the oil chamber are fully leak-tested, for which provision is made in the design.

The general dimensions are 12 ft. diameter and 4 ft high. A 16 ft. vertical boring mill is used for boring and facing operations, and here dimensional accuracy is again important as the build-up of the whole machine starts with the bearing housing as the datum line. There is much detail drilling on all the faces for the bracket arms, the pipework, bearing access covers, etc., calling for many hours work marking-out, radial arm and portable drilling.

Fig. 14

Fig. 15

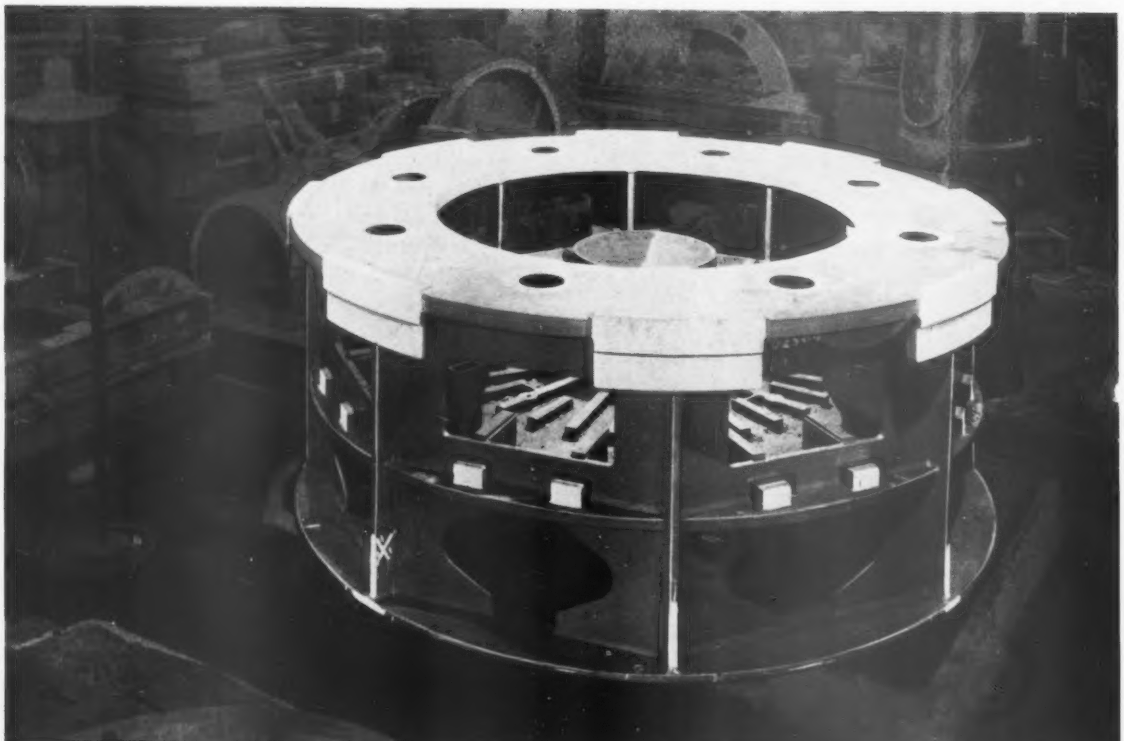

Fig. 16

(l) *Bottom Bracket Arms*

The bearing housing is carried on eight fabricated steel arms 96″ long and 62″ high. These arms "hook" under the housing and bear against the outside diameter. They are each secured by eight 2″ bolts although by design the bolts carry no weight. Each arm carries on its upper side a facing for the double brake cylinders.

A machining set-up similar to that described for the rotor spider arms is used, the arms being set on radial lines and bored and faced at one setting. Drilling is done to marking-out and is performed by large radial arm and portable machines.

(m) *Details*

Some of the smaller items are of considerable magnitude from the man-hour content point of view. The half-round pole end pieces, of which there are 72 on this machine, require 15 operations on 7 different machine tools before they are ready for assembly to the pole laminations.

The pole retaining keys, 144 in number, are 50″ long and have to be milled all over, including a 1 in 50 taper. They are matched in pairs, one being black steel and the other chrome-molybdenum steel. A special long table milling machine is required for this purpose and cutter wear on the chrome-molybdenum keys is heavy.

The brake cylinders and pistons are items that require special attention because of the accuracy and finish demanded on such vital parts. The cylinders were originally called for as castings, but severe trouble with leaks necessitated a change in design to fabrication.

The quantities of special taper and fitted bolts, core-building studs, dowels, etc., require careful attention in the machine shops if manufacture of the complete machine is not to be held up. It is surprising how often such parts cause more risk of delay than the larger and perhaps more obvious items.

A very considerable quantity of air, oil and water pipework, although constructed whenever possible of

Fig. 17

standard bends and flanges, has to be programmed to meet the various sub-assembly stages, and takes two pipe fitters about six weeks to fit, apart from the actual manufacturing time.

Assembly

A machine of this character is normally fully erected and tested at the manufacturer's works in order to minimise the time taken to get the machine into commission after delivery to site; to discover unsuspected snags, and to carry out electrical running tests which may either be inconvenient or impossible on site. The maintenance of a strict assembly and test programme becomes of vital importance when one considers the large areas of shop floor taken up with the sub and main assemblies of such large machines.

The main erection procedure follows the following general outline :-

The general shaft is placed in position with its coupling flange suitably supported on the floor of a special test pit. The thrust bearing housing with its eight bottom bracket arms is then lowered over the shaft on to heavy sole plates positioned to receive it.

The spring plate, spring assemblies and bearing pads are assembled in the bearing housing, at which stage the shaft is lifted up to a position several inches higher than normal and packed up from the bottom of the pit.

The thrust block assembly is now lowered on to the shaft and pressed home into position on its seating by means of special forcing tackle made for the job, and which will accompany it to site. After retaining keys have been fitted, the guide bearing, brake cylinders and all associated pipework are assembled and checked.

The assembly is now ready to receive the rotor spider hub, which is pressed on to the shaft and keyed, using methods similar to those employed in mounting the thrust block. The shaft is then lowered to give approximately $\frac{1}{4}''$ clearance between the thrust face and the bearing pads.

The rotating field assembly, comprising the eight spider arms with securing rings, the laminated rim and its poles and field coils is lifted as a complete unit and lowered on to the rotor hub (Fig. 17). This is the biggest single lift made during the assembly operation and is determined by the lifting capacity available. The weight could have been reduced by waiting until the rotor was in position before assembling the poles and coils. Fitting the taper bolts securing the clamp rings to the rotor hub completes the rotor assembly.

The stator, (shown in progress, Fig. 18) which has been assembled into a full circle and the coils covering the four joints wound in and connected, is lowered over the rotating field and secured to suitable sole plates which have been pre-positioned and clamped down. The position of the stator is adjusted to give an equal air gap around the rotor and it is then heavily braced with timbers to ensure maximum rigidity.

The top shaft assembly carrying the governor generator rotor and exciters, armatures, etc., is set true and coupled to the main shaft after which the assembly of the top gear proceeds. Exciter fields, governor generator stator, platforms, covers and supports are fitted, followed by the coolers, pipework, oil tanks and pumps. During this time, all the necessary electrical connections both on and to the machine are being made.

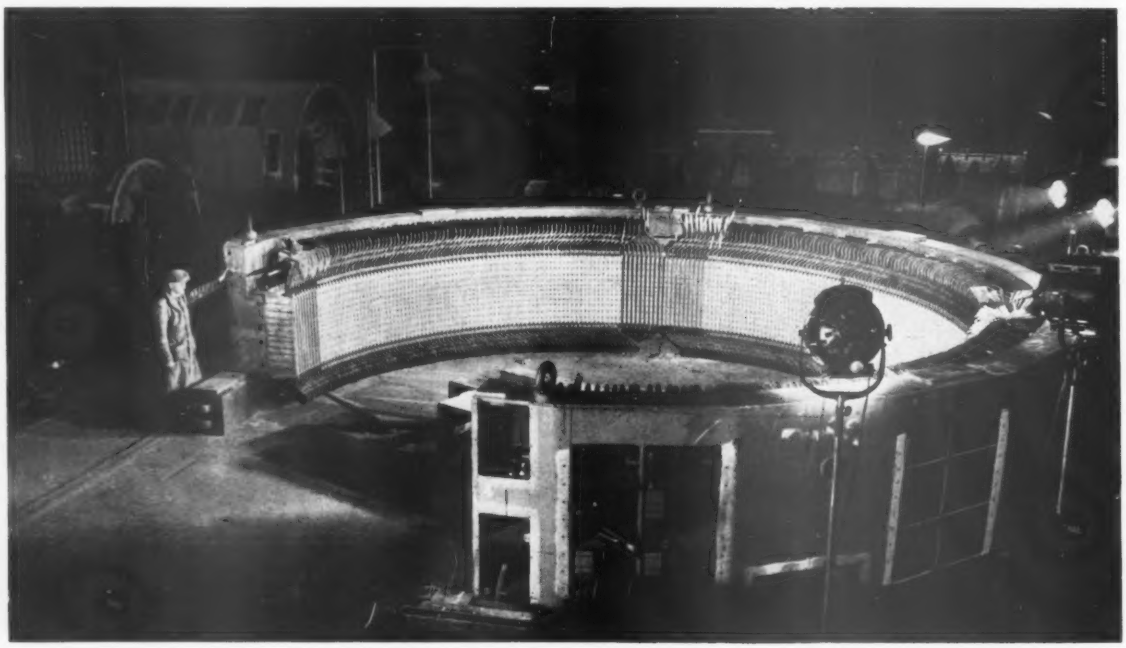

Fig. 18

Finally the rotor is lifted by the brake blocks, acting as jacks, the shaft packings removed, the bearings cleaned by flooding with oil, the oiling system checked for pressure and quantities and the machine is ready for running.

Testing

The major tests carried out on this machine in order to establish that it met all guarantees were :—

Determination of efficiency;

Determination of voltage regulation;

Determination of temperature rise under full load conditions including measurement of air volume and pressure;

An overspeed test at 350 r.p.m. (110%) for one minute;

Oscillograph records of three-phase sudden short circuit at 5,500 volts, line to line wave form at 11 kV, and line to neutral wave form at 11 kV;

Retardation test;

Insulation and pressure tests under hot conditions;

Brake-jack tests including oil pressure to lift rotor, air pressure to operate brakes and the actual brake performance.

It is not proposed to deal in detail with the methods of carrying out these tests, but it is worth mentioning that very considerable test capacity is required, and some ingenuity in using outside power supplies in conjunction with the motor generator sets and reactor equipment normally carried on a large electrical test-bed is called for.

Efficiency is checked by measurement of friction and windage losses, iron loss and copper loss. For this purpose the machine is run synchronously as a motor at unity power factor, being supplied from a test motor-generator set.

The most involved test to carry out is the measurement of temperature rise under full load conditions. It will be readily understood that it is impossible to test a 33,300 kVA machine under actual full load, but a method exists of simulating full load conditions using a wattless load. Even then a considerable amount of special plant is required. By this method the stator is loaded with full load current at full voltage, but at zero power factor. No power is actually consumed other than that required to supply the losses. The plant involved in this test consisted of a 6,000 kVA M.G. set, a 10,000 kVA M.G. set, a 3,000 kVA transformer and two 20,000 kVA reactors.

The overspeed run is probably the most difficult test to undertake. A 100-cycle alternator was used in conjunction with two existing D.C. machines to form a motor generator set. Power was taken direct from the substation by two feeders, to the A.C. side of the two test M.G. sets which were connected to the two D.C. machines of the 100-cycle M.G. set. A total input of 3,700 kW was required. This factor, apart from the inherent danger of such an overspeed run, necessitated the test being done outside normal working hours. All personnel, instruments and controls required to conduct the test were housed in an underground chamber to minimise risk in the event of any unforeseen structural failure in the machine.

Dismantling and Shipping

After all adjustments have been made and tests carried out to the satisfaction of customer's engineers, the machine is dismantled into its component parts for shipment. As this proceeds, all parts are carefully stamped and marked to facilitate erection on site. Each part is cleaned and painted, all machined surfaces being protected with a special rust preventative, and passed to the shipping section after a final inspection. Here every item is checked against a shipping list before being packed into crates which have previously been ordered for this purpose.

The packing and shipping of such a large machine is a complex undertaking. The question of the suitability of road and rail transport, the handling facilities at the ports concerned, the sequence of shipments and the adequacy of protection have all to be taken into account, and frequently have an effect on the initial design of the machine.

Perhaps one of the most striking features in the manufacture of large waterwheel generators is the absolute necessity for the closest cooperation between the Production Engineers concerned and the engineering department responsible for the design of the machine—a cooperation which, in the case of the generator described, was of the highest order.

B.I.M. CONFERENCE

The B.I.M. Annual Conference takes place this year at Harrogate, from 11th to 14th November. The Institution of Production Engineers, together with the Institute of Engineering Inspection, has been invited to take part in one of the main Sessions, dealing with "Quality Management". The Institution's representative on this occasion will be Mr. S. W. Nixon, Member, Chief Inspector of the Rover Co. Ltd. Mr. Nixon is a member of the Research Committee and of the Materials Utilisation Sub-Committee.

BRITISH STANDARDS

The following Standards have recently been issued and may be obtained, post free, at the prices stated from the British Standards Institution, British Standards House, 2, Park Street, London, W.1 :—

B.S.1660 Part 2 : 1953. Cotter Slots (4/-).

B.S.1660 Part 3 : 1953. Quick-Release Tapers (4/-).

B.S.2009 : 1953. Acceptance Tests for Turbo-Type Compressors and Exhausters (10/-).

B.S.2012 : 1953. Mould Die Sets for Injection Moulding Machines (2/6d.).

ISSUE OF JOURNAL

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

MANUFACTURING METHODS OF FRACTIONAL H.P. ELECTRIC MOTORS, AS SEEN IN SWITZERLAND AND A GLIMPSE AT SOME GERMAN TELEPHONE MANUFACTURING METHODS AND ADMINISTRATIVE PROBLEMS

by D. C. HOWARD, Grad.I.Prod.E.

Presented to the London Section of the Institution on Monday, 11th May, 1953.

Mr. D. C. Howard

Mr. Howard was educated at the Glendale County School and Northampton Polytechnic. He studied at Coventry Technical College and at Northampton Polytechnic for his Higher National Certificate in Production Engineering which he obtained in 1947, being awarded prizes by Wickman, Limited, in 1946, and by the Worshipful Company of Skinners, in 1947.

Mr. Howard served a seven-year indentured apprenticeship with Standard Telephones and Cables, Limited, during which time he underwent special training for a year with Wickman, Limited, and for three months with the Bell Telephone Company at Antwerp. On completing his apprenticeship he was appointed a Motion Study Engineer with Standard Telephones and Cables, Limited. He is now Assistant to the Head of the Ratefixing and Estimating Department of the same Company.

PART I

THIS Paper is divided into two parts and covers my study project carried out on the Continent from June to December, 1952. The first section deals with the first two months, which were spent at the Brown Boveri Company in Baden, Switzerland.

During my stay with this Company I was attached to the department known as the "Factory Study Bureau", whose chief function can best be described as "Production Rationalisation". Working in this department of a vast organisation provided an excellent opportunity for studying many interesting aspects of production, ranging from factory layout to the carrying out of aptitude tests on blind workers.

I have, however, singled out the production of fractional horsepower electric motors as the subject of the Paper, because the Motor Factory is claimed to be the most modern and efficient of its kind in Europe.

A few words of introduction are included concerning the development of Brown Boveri, to help to put the Motor Factory into perspective with relation to the rest of the Company.

Brown Boveri Company was founded in 1891 by Charles Brown and Walter Boveri at Baden. Brown, the son of an English mechanical engineer, was born in 1863 at Winterhur, where he studied electrical engineering, and in 1884 he joined his father at the great Oerlikon Works in Zürich. Walter Boveri, who was two years younger than Charles Brown, was the youngest son of a doctor. After completing his studies in mechanical engineering at Neunberg, he too joined the Oerlikon Company. When the B.B. Co. factory was founded, it consisted of three workshops and a collection of converted dwellings, many of which are still in use today. During its sixty years of development it has grown from a small undertaking

employing some 148 persons, into a world organisation having a staff of more than 40,000. Of this total some 8,000 are working in Baden. The present factory site covers an area of more than one million square feet, bounded by steeply rising hills on the West and the main railway line between Zürich and Basle on the East. The enormous scope of the manufacturing organisation has resulted in the dividing up of the Company into seven factories. In the main, these factories are classified according to the articles they produce and are all managed at top level by one General Factory Director, who shares parallel responsibility with four other managers, namely: the Directors for thermo-dynamic techniques, electrical techniques, commercial affairs and general administration.

A brief idea of the enormous scope of the manufacturing programme can be gained from a selected few of the firm's technical developments.

In 1897 a generator for the supply of electricity was constructed which delivered 8,000 volts. This was the highest tension generator built up to that time. Four years later, the first steam turbine on the Continent and the largest of its kind in the world was manufactured at Baden. With the increasing demand for electrical energy, the Company began to expand rapidly and produced almost every type of equipment used in power generation and transmission. In 1933 Brown Boveri brought out their patent compressed air operated circuit breakers for 13,000 volts, which are now one of the Company's standard line products. By 1935 the demand for small electric motors was considerable, especially by machine tool companies, and the production of these was undertaken in Basle. As early as 1937, gas turbine compressors had been constructed and in 1949 the Company produced a gas turbine power unit for British Railways. In 1951 a 31 MeV Betatron was built for the Canton Hospital in Zürich. The highlight of 1952 was the production of a steam turbine driven generator having an output of 110,000 kW, the largest ever made in the Baden factory.

Spectacular though these achievements may be compared with the manufacture of small electric motors, the visitor cannot help being impressed by the design, layout and organisation of the new Motor Factory, and the liquid-like manner in which these motors flow off the production line.

The New Motor Factory

This factory was built to meet the demands for increased production. The original factory in Basle was, therefore, used as a starting point for the Study Group whose responsibility it was to lay down all the requirements of the new plant. It is significant that the plans were formulated in great detail before the new factory was completed, to the extent that the whole of the organisation and production principles were established before production was due to commence.

The electric motor factory employs nearly 500 persons and is largely independent of the rest of the Company except for the functions of Sales, Product Design and General Management, so the situation of the factory within the organisation of B.B Co. corresponds to that found in most large companies. The manufacturing programme embraces electric motors and generators ranging in capacity from 100 watts up to 150 kW and this range is divided into the following product groups:

(1) Alternating current motors from 100 watts up to 7.4 kW.

(2) Alternating current motors and generators from 1 kW up to 100 kW.

(3) Direct current, commutator motors, rotary converters, generators and traction motors ranging in capacity from 0.5 to 150 kW.

The factory consists of two principal sections referred to as the B.F.1 and B.F.2. The B.F.1 factory manufactures only the motors in group (1), that is AC motors of the induction type up to 7.4 kW, while the remaining ranges are manufactured in the B.F.2. This division between the B.F.1 and B.F.2 is based on batch sizes. The greatest demand is for small standard type AC motors which, because of the number required, lends itself to large batch production methods for which the B.F.1 is designed. The B.F.1 plant has an annual capacity of 60,000 motors in more than 48 sizes and types, and the B.F.2 plant can produce between 14,000 and 15,000 motors of an even greater variety. This capacity is more than twice that of the old Basle factory.

When the factory was designed, no special attention was paid to the product to be manufactured. The main consideration was to set up a building with all necessary amenities, which could be utilised to the best advantage irrespective of the type of goods to be produced.

The general arrangement of the new building is shown in Fig. 1. The factory is made up of three large bays each measuring 58 ft. x 412 ft. and along the south side there is a three-storey block 58 ft. wide with two tower-like structures which accommodate the stairways and goods lifts. The general structure is of steel with reinforced concrete floors and walls. The floors in the high building have a loading capacity of 3 tons per square yard. The bays are freed from obstructing columns by the 58 ft. roof spans and the sawtooth roofing fitted with Thermolux glass, together with the large expanse of windows, give excellent lighting conditions. The lighting is augmented by white fluorescent tubing, and the factory is ventilated and heated by convector heaters fitted on the roof supports.

Accommodation for the Administrative Departments is unique. Between the ground floor and the first storey, there is a lightweight flooring extending from the east end of the building to the centre stairway. The offices are partitioned off by metal frameworks and oak panels which are of a temporary nature, to permit easy alteration which circumstances may demand. The space below the lightweight flooring, which has a 10 foot headroom, is used as a Finished Parts Stores.

The east wing of the building is not used for motor production but the basement houses the toilets, cloakrooms, power transformers, switch gear and other services. The distribution system for the factory

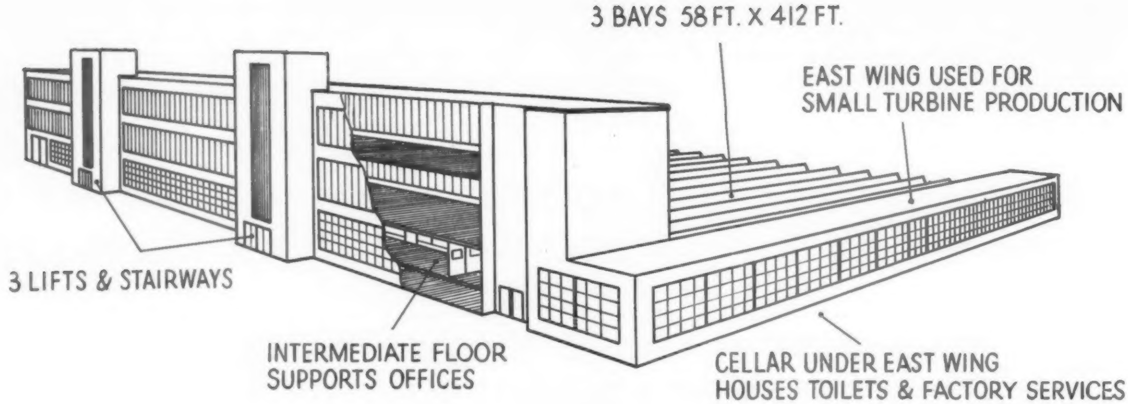

Fig. 1. Arrangement of new Factory

services of electricity, compressed air, water and gas, feeds main arteries which run longitudinally under the floor following the line of the girders supporting the roof spans. Main distributor boxes are mounted on these girders and transverse canals in the floor carry the services to the machines and installations.

These canals are covered with removable steel plates fitting flush with the wood-block flooring. This makes it possible for almost all wiring and piping to be kept out of sight and yet it is easily accessible for alteration or maintenance.

The factory railway line which runs through the new building, enters at the south-west corner through a 15 ft. square doorway. The detailed planning involved in setting up this factory is a typical example of the procedure used by B. B. Co. in planning all their layouts, and although they may seem over-elaborate, the results appear to justify the expense. The planning is divided into four main stages. The production methods are firstly established in principle with reference to design for production and the plant and equipment which is to be installed. A block plan is then drawn up to a scale of 1/500. This represents the basic floor layout from which a further plan, worked out in greater detail, shows the arrangement of machines, work places, and material storage space. A three-dimensional model is then made to a scale of 1/50. The floor of the model factory is of Plexiglass, which makes visible the distribution system of power, air, water and gas under the floor painted on the baseboard of the model. Much of the detailed work connected with these models is undertaken in their spare time by factory workers who receive some remuneration for making up the models of machines, etc. Time-consuming and expensive though these models are, they do present the proposed layout in a most realistic manner, and can bring to light weaknesses in the plan which otherwise might not be recognised until it is too late.

The Study Group, in addition to their responsibility for the general specifications of the factory, also had to solve the problem of planning the organisation of a flow-line which would be sufficiently elastic to cope with the demands of the Sales Department for an annual production of 60,000 motors. It was agreed between the Sales Department and the Factory that the time required to execute an order for a motor should be established as eight weeks. This was based on sales figures for 1947 but has since been further reduced to six weeks. This period of time does not affect the delivery date to customers, for a minimum stock of motor parts ensures the complete execution of an order within six to eight days. The necessity for holding a buffer stock was one of the main factors in planning the flow-line. To reduce double handling of parts, buffer stores were set up between the machine line and the assembly line. These stocks of castings in particular are rather large, being 50% of the current programme. This buffer stock of castings is large because B. B. Co. has no foundry and they are held to cover delays from the suppliers.

The Principle of Flow-line Motor Production in B.F.1

The manufacture is divided into the following basic sections :-

(1) Production of the shaft and rotor;

(2) Machining of the stator housing and end covers;

(3) Assembly of the windings into the stator;

(4) Final assembly of the motor.

Even though the range of motor sizes is fairly extensive, there being more than thirty standard varieties, the manufacture of the shaft, rotor, stator and end covers all have a relatively uniform production time. The greatest differences in manufacturing time are found in the assembly of the stator windings, which vary from the smallest to the largest motor in the ratio of one to eight.

The flow-line of the B.F.1 is represented diagrammatically in Fig. 2. Raw material enters the factory

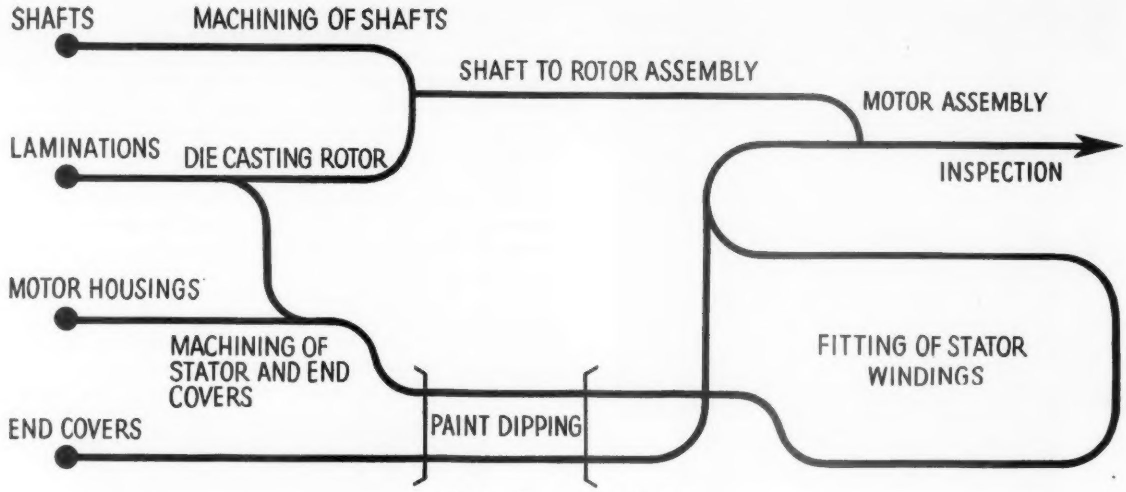

Fig. 2. Flow line of the B.F.1

by rail at the west end of the bulding, where it is stored in four groups, round bars for shafts, magnetic iron sheet for laminations, frame castings and motor end covers. The seven stages of production of the motors will now be described in some detail.

(1) *The Motor Shafts*

These are made from low-carbon mild steel bars which are fed to an hydraulically operated cut-off saw which cuts to length four bars at a time. The machine cycle is fully automatic, it being necessary only to feed new bars to the machine. As the material is cut, the shaft blanks are placed on five-tier wheeled racks which are used universally throughout the factory, not only for storing the work during the operating, but also for transporting it through the works. The sawn blanks are then centred each end in preparation for the turning operation, which is carried out on the two George Fischer hydraulic copying lathes shown in Fig. 3. The machines are semi-automatic and are arranged facing one another so that they can be attended by one operator. One machine is set to turn four diameters on the front end of the shaft, while the second machine is set up to turn the opposite end. The two machines are used to avoid changing the profile plate which controls the cutting tool. Originally the shafts were centre turned, but the new method of profile turning has reduced the machining time by as much as twenty minutes. The turned shafts are then ground between centres. The final machining operation is the milling of the keyway in the driving end of the shaft. Fig. 4 shows how the operation of milling and drilling is combined by using a specially designed machine which handles six shafts simultaneously. The completed shafts are now ready to be pressed into the rotors.

(2) *Production of Rotor and Stator Laminations*

The laminations are blanked from magnetic iron sheet which is pre-cut to suit the guide ways of a conventional pierce and blank follow-on tool mounted

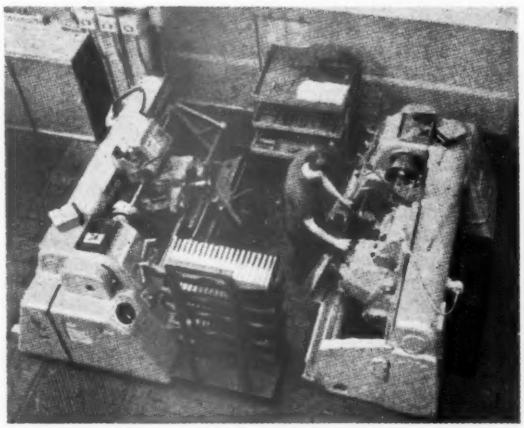

Fig. 3
Turning of Motor Shafts

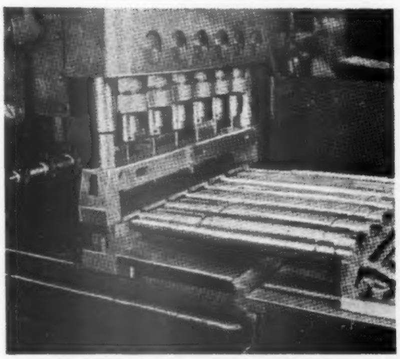

Fig. 4
Milling Keyway in Motor Shafts

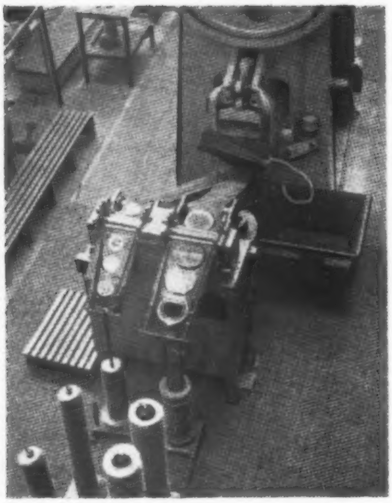

Fig. 5
Blanking Rotor and Stator Laminations

in a 120 ton press. The press is equipped with a pneumatically operated automatic stack-feeding device. This mechanism is fitted at the feeding side of the press and transfers the top strip of material from a stack to the power driven feed rollers. These are set to advance the material through the tool, the exact pitch being controlled by six pilot punches. Fig. 5 shows how the rotor and stator blanks are collected from beneath the machine. The press runs at fifty-eight strokes per minute, and a stator and rotor blank are produced at each stroke. Since the tool is not a compound type punch and die, the blanks and piercings fall through the die aperture. The laminations are blanked paper side uppermost, and fall onto the moving canvas belts, which carry them up to two pairs of driven rollers and, the lower one being of carborundum, any burrs on the blanks are removed. The finished blanks are then stacked automatically on long rods mounted on small wheeled bogies, used to transport the work to the next operation.

The scrap piercings are removed from beneath the press by a miniature bucket conveyor which carries them away and tips them into a large swarf bin, while the remaining scrap from the strip is cut into short lengths by a cropping blade as it leaves the press.

(3) *Manufacture of Rotors*

The first step is the preparation of the rotor laminations. The quantity required is determined by weight. The rotor body is die cast in an aluminium alloy using a Cold Chamber Machine. The required stock of laminations is mounted on a dummy shaft which is in effect an insert for the die casting tool. The aluminium fills up the slots in the laminations forming the conductors, and the motor cooling fans are cast integrally at each end of the rotor. When the sprue and dummy shaft have been removed, the rotor is ready to be pressed on to the motor shaft. The outside diameter of the rotor is then lightly machined to ensure concentricity with the shaft. Originally the rotors were turned and ground but the life of the wheels was short owing to the clogging caused by grinding the aluminium, and turning alone did not give the necessary accuracy of finish. These difficulties were overcome by using an American rotary shaving machine shown in Fig. 6. In this method, the work rotates slowly between centres while the multi-tooth cutter rotates in a counter direction. The axis of the cutter is at an angle to the rotor which passes longitudinally under the cutter. This new method not only gives a very satisfactory finish, but also reduces the machining time by ten minutes per rotor.

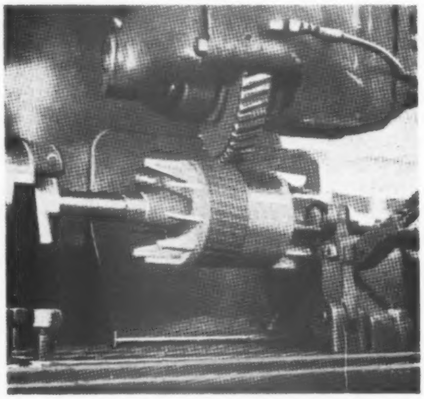

Fig. 6
Rotary Shaving of Rotor

The final operation and one of the most important is the balancing of the finished rotor shown in Fig. 7. The earlier method used for dynamic balancing employed a swinging frame machine in which the work

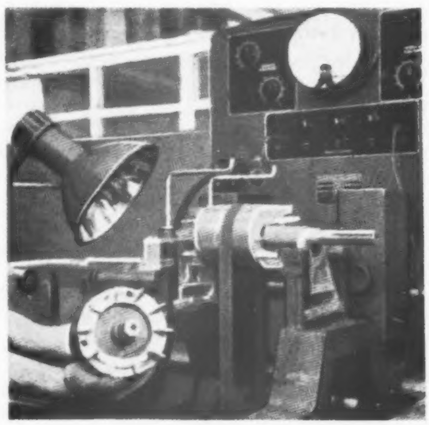

Fig. 7
Balancing the Rotor

was mounted between centres, one of which was driven. Correction of the unbalanced rotor was made by marking the heavy side with a pencil and lightening by drilling holes in the rotor ends. In the new machine, the journals of the rotor shaft rest in half bearings. These bearings oscillate when vibrated by the unbalanced rotor which is driven round by a light belt as shown. The oscillations set up in the bearings are transferred to a stroboscopic lamp which shines on a ring of numbers cast in an annular slot in the ends of the rotor. The number which becomes visible during rotation under the stroboscopic lamp indicates the lightest point of the rotor, and correction for out of balance is made by inserting a small metal slug of known weight in the die-cast slot and securing it with a punch. Not only is this method extremely rapid and easy to operate but a very high degree of accuracy is obtainable, the centre of gravity of the finished rotor being within 0.001 mm. (approx. 0.00004").

Finally the ball races are fitted to the shaft, the finished assembly wrapped in protective waxed paper and transported to the assembly area on wheeled racks.

(4) *Machining of the Motor and Covers*

From a single storey structure on which the end cover castings are stored at the beginning of the production line, a labourer hangs the castings on the chain conveyor built at a height of 10 feet above floor level. This conveyor, part of which can be seen in Fig. 8, has a length of 116 feet. The conveyor system

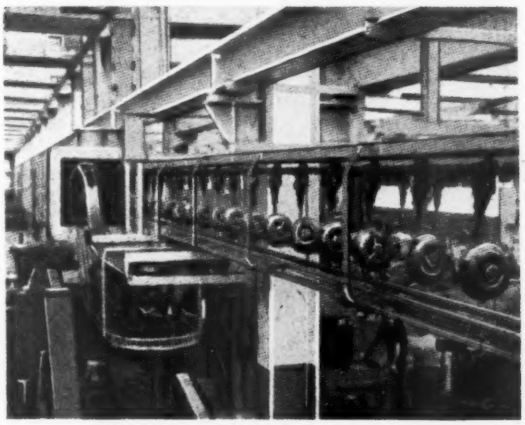

Fig. 8
Conveyor and Paint Dipping Booth

comprises two parallel but independent chains, one for transporting the end covers as seen on the right of the illustration, and the other for the transport of the stator housing. Both these moving chains carry the work through a 770 gallon dipping tank and drying chamber. The motor end covers are dipped and dried prior to machining, which ensures that the machined bores for the ball races are free from paint, thus eliminating a masking operation which would be required if the castings were painted after machining.

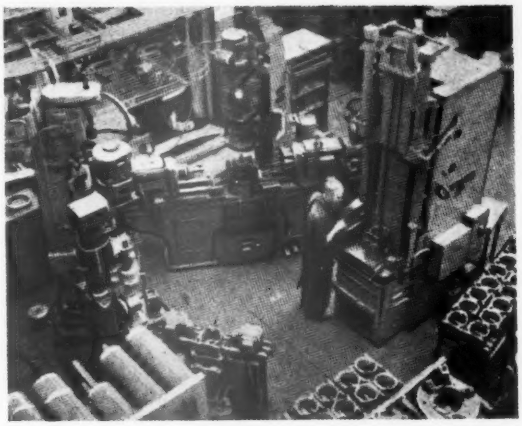

Fig. 9
Machining of the Stator Housing

The covers are collected from the chain automatically and delivered down a short roller conveyor to an eight-station Bullard vertical automatic lathe. On this machine the major diameters are turned and the bearing housing is rough bored. The drilling of fixing holes is also carried out, using a multi-spindle drilling head. This is accomplished during the machine cycle, by preventing the rotation of the end cover while the drill head descends to carry out its work. The flanged type covers for motors designed for axial mounting are machined on turret lathes. Drilling of the fixing holes in the flange is carried on simultaneously with the turning of the outside diameter, by using a specially designed multi-drilling head mounted in one of the tool positions on the turret block. When the turret is advanced towards the revolving work, a driving dog on the chuck engages with the drilling head and rotates it. The rotational movement drives the drills themselves through a gear train and as the turret is further advanced the holes are drilled. Finally, the bearing diameters for the races are fine bored on twin spindle vertical boring machines and the completed covers are transported in wheeled crates to the final assembly area.

(5) *Manufacture of the Stator*

The stator castings are stored under the end cover store mentioned in the previous section, but in this case the castings are machined prior to being painted. One end of the casting is turned on a small vertical mill and then fed to a Bullard eight spindle vertical automatic which finish turns the inside bore, flange diameters and recesses. A short roller conveyor carries the stator castings to the next group of machines shown in Fig. 9. This group consists of five machines which are operated by two men. Here the casting has a keyway broached in its bore to locate the stator laminations and all holes are drilled and tapped. The multi-spindle drilling machine in the centre of the illustration is rather interesting. It is built up of three separate motorised units, each of which is fitted with a multi-spindle drilling head. The head on the left of the machine is capable of being

rotated about a vertical axis so that holes may be drilled horizontally at any required angular position. The stator is clamped hydraulically and the machine is controlled by push buttons. Also notice how the machines have been arranged around the worker, giving the minimum transport distance between each of the five operations.

The machining now completed, the castings arrive by roller conveyor at the next work station, where the laminated stator is built up. The laminations are selected by weight as they were for the rotor and the required quantity are secured in the stator casting under pressure by a heavy " C " ring, a fibre lamination being included at each end of the rotor to prevent windings being chafed by the sharp edges of the blanks. The sharp edges from the axial slots in the stator are removed on an automatic indexing filing machine and the finished stator housings are hung on the conveyor to be paint dipped. The dry castings leave the end of the chain conveyor ready

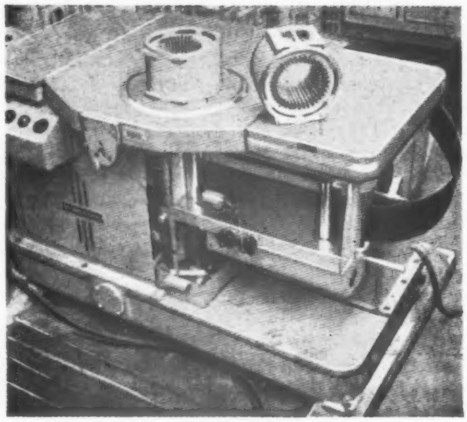

Fig. 10
Automatic Slot-Insulating Machine

Fig. 11
General View of Winding Assembly

for the insertion of the stator slot insulating paper. The machine shown in Fig. 10 was designed by B. B. Co., and is capable of insulating the stator at a rate of more than three thousand slots per hour. The stator is located on an annular disc in the table which is indexed according to the number of slots in the stator. A reel of insulation paper is fed into the machine which cuts a strip from the end of the required width and folds it into a " U " shape. A vertically reciprocating arm then carries it up through a guide aperture in the machine table and inserts it in the stator slot. The stator then indexes to bring the next slot in the laminations over the aperture and when all the slots have been filled the machine is automatically stopped. A number of interchangeable annular discs and a set of change gears enable the machine to cope with the various sizes of stators.

(6) *The Winding and Assembly of the Stator Coils*

Little need be said regarding the winding of the individual coils which go to make up the complete stator winding. Four Micafil coilwinding machines are used and the coils are wound on collapsible wooden mandrels. Three or four coils are wound simultaneously according to the type of winding required and these elongated coils are labelled up and stored on wheeled racks, one of which can be seen in the bottom right hand corner of Fig. 11. This picture shows the new layout of the stator winding assembly area. It consists principally of an endless conveyor some 800 feet round which moves in an anti-clockwise direction and has benches arranged down its two sides in herringbone fashion. The stator castings are fed on to the conveyor, together with the appropriate coils, which are then assembled in the stator slots and secured in position with strips of wood driven into the lamination slots. The assembly work is carried out by women. This work, under the original method, was very fatiguing owing to the amount of handling of the heavy stator during assembly of the coils in the slots. A special jig was, therefore, designed which enabled the work to be swung into any desired position. The stator is clamped in a light ring which can be rotated and swivelled. This ring can be locked in any position and is carried on a vertical column which can be raised or lowered hydraulically to the desired working height. When the individual coils have been assembled and secured in place, the stator travels along the conveyor to the finishing positions where the coils are joined and the terminal leads attached to the windings. The connection of the copper wire is made by twisting the two ends together and welding them with an acetylene torch. This method has been found very satisfactory and is considerably cheaper than soldering, because the joints are made without removing the enamel from the wire and neither flux nor solder is required. After the lacing up of the finished windings they are given an electrical breakdown test and are then dried out, varnished and stored.

(7) *Final Motor Assembly*

We now come to the final stage in the production of the motor. The finished stators are placed on pallets and fed down a 65 foot roller conveyor at the side of which stand the assemblers. The operation consists of fitting the two end covers and rotor assembly together. The small details, like terminal blocks and covers and fitting the key in the motor shaft, complete the assembly and the motors pass down the conveyor to be tested. With the testing complete they are given a final coat of paint in a spray booth at the end of the conveyor. The dry motors are then fitted with their identification plates and leave the B.F.1 for shipment at a rate of one every two minutes.

Motor production in the B.F.1 section reached its peak in 1951, when 54,000 motors were produced having a factory price of just over 7,000,000 Fr. Since that time the average monthly production has fallen from 4,500 to 3,500 during the summer months of 1952. In May, 1952, 3,630 motors, having a factory price value of 482,000 Fr., were manufactured in the B.F.1 with a total of 104 workers, thus making the work value 60,000 Fr. per employee. These figures show a reduction in manufacturing costs of between 20% - 25% compared with the old Basle Factory. This reduction in manufacturing costs has been realised through the improved manufacturing layout and production techniques which have been outlined in this Paper.

In concluding the first part of my Paper, I cannot overstress the importance which I found Swiss companies place in applying the techniques associated with what has been expressed as " Production Rationalisation ". No doubt the term " Work Study " is more familiar to us in Britain, but regardless of the label which the technique bears, the same four basic aspects are embraced, namely: Methods Study, Motion Study, Time Study and Job Evaluation, and whether these four aspects were applied singly or collectively to the problems associated with the improvement of production methods and management techniques, the most effective results were observed in establishments where both labour and management had confidence not only in a scientific approach to the raising of productive efficiency, but also in each other. On the whole, the Swiss appear to have this confidence and an attitude of mind exists which has been conditioned to the successful working of plans for increased productivity, a state of affairs which is of vital importance if new and better methods of production are to be successfully introduced. I am firmly of the opinion, even after contact with only a few Swiss firms over a short period of time, that the high rate of productivity which is associated with their industry is not due to vastly superior craftsmanship, equipment, tools or methods, but to a deeper appreciation of the necessity to work and to a more objective outlook. As far as the four aspects of Work Study mentioned previously are concerned, the Swiss have little to teach us except in their attitude towards its application. Almost the entire training and practice of Work Study techniques follow the literature of American origin. Considerable interest is being shown in the methods of training for Work Study, which are rapidly expanding in this country and, like Germany, Switzerland hopes to

establish recognised training courses on a national scale. There are many disciples of the "Methods Time Measurement" technique found in America and the opinion seems to be that if productivity is to be raised it must firstly be measured and, to do this, some attempts have been made on a small scale to set up standards of reference and units of measure for work.

Some evidence of this was found in Germany which has been developed from what is referred to as the R.E.F.A. system. The development of this system is of particular interest not only for the contribution which it has made towards the raising of Germany's industrial productivity, but more especially because it is already established on a national basis throughout Germany.

In both America and Britain there has been, since the time of F. W. Taylor, a variety of time study, motion study, work measurement and other pet names for so-called sciences which have been applied by management in an effort to raise productive efficiency by a rational approach to the improvement of methods and to the solution of the less tangible problems associated with incentives, and so to the long list of alternative names for "Work Study" is added yet another—the R.E.F.A. system.

What is R.E.F.A. ?

R.E.F.A., as it is referred to colloquially, is fundamentally a system of time study, but it is something more than just another technique to be adopted when making stopwatch studies. The wider conception of R.E.F.A. is that of an industrial association for both men and managers which through a basic and conscientious examination of work, provides a basis for the calculation of wages and for the improvements of methods and management. The letters R.E.F.A. are the abbreviation for its German title "REICHSAUSSCHUSSES FUR ARBEITS-ZEITERMITTLUNG", the literal translation of which is "NATIONAL COMMITTEE FOR WORK TIME MEASUREMENT" and, although much of the work of F. W. Taylor and the Gilbreths is reflected in it, it is to no man that R.E.F.A. owes its birth, for the system has its roots in Germany's industrial and political past.

Towards the end of 1921 a commission was set up, under the Union of German Metal Workers, to investigate the problems of finding a suitable basis for the calculation of wages to overcome the anomalies in the old system of the "standard wage agreement". (At this particular time, Germany was on the brink of inflation and the purchasing power of the Reich Mark was rapidly on the decline). The three principal bodies who were responsible for the large scale investigation into the methods used to measure work and calculate wages were the Union of German Metal Workers, the Committee for Economic Industrial Organisation (formerly the Committee for Machine and Manual Work), and the Association of Industrial Managers, and on September 30th, 1924, R.E.F.A. was founded.

During the years 1927 - 1928 the R.E.F.A. system was introduced into the metalworking, china, pottery and chemical industries and the results obtained from the scientific approach to improvement of methods and the establishment of sound bases for the calculation of incentives were very encouraging, so much so that the R.E.F.A. system spread rapidly through the whole of German industry. With the increasing application of R.E.F.A. there came the demand for men trained in this new technique and in the autumn of 1935, in combination with the "German Front", special courses were organised on a national scale to train the necessary men. Between 1935 and 1939, more than 5,000 R.E.F.A. men were trained and by the end of 1945 the number had risen to over 30,000. The recognised national training scheme has been largely responsible for the wide acceptance of the R.E.F.A. system, and considerable evidence of its growth is shown by the fact that it is being applied in almost every factory. The success with which managements have applied the R.E.F.A. system is largely due to the fact that on one practises the technique of time study on the factory floor for the determination of work time, either as a basis for the calculation of wages or for methods improvement, unless the time study man has attended the recognised R.E.F.A. training course.

However, in spite of the wide acceptance of scientific aids to management, it is questionable whether Germany is as far advanced in their objective application and, in other directions, they are considerably behind British industrial management. One factor which has not been recognised to be of the utmost importance in the campaign to secure higher productivity is that of industrial safety. There appears to be, in the Continental factories, an almost complete indifference towards the use of devices for the safeguarding of the workers against accidents.

In one Swiss factory the management had recently launched what they considered to be a "Safety Campaign". This could perhaps have been more successful if it had been more objective. A rather gruesome photograph of one of the firm's employees was displayed throughout the works, showing the head injuries received through the employee's hair having been caught up in a machine, but nothing was done to guard the machine. This kind of approach may be effective to a degree, but if it merely instills fear into the workers, there is not likely to be the productive effort one would expect from persons working in safety without the shadow of danger hanging over them. Nevertheless, even though in many cases working conditions and amenities are below the standard demanded in Britain, I found, both in Germany and Switzerland, a working tempo in the majority of factories that would embarrass many industrial undertakings in this country. This tempo is mental as well as physical. There seems to be in the mind of the worker, be he labourer or manager, a sense of responsibility to the community at large which drives him to work hard and long.

In the foregoing section of this Paper, I have tried to convey by a brief description of electric motor production, some idea of the manufacturing methods employed by an organisation which, although small in itself, is part of a very large industrial undertaking.

Nothing has been said regarding the production administration departments of the motor factory whose responsibility it is to plan, direct and control the manufacture of the product. The problems of these departments are relatively small when the manufacturing unit is decentralised, so that it is concerned only with the production of a limited range of items, as, for example, the parts which together make up electric motors of the induction type just described. The problems of the production administration departments increase at an alarming rate with the complexity of the production organisation. To illustrate the problems associated with an organisation which is engaged in the manufacture of a more complex product, I now pass on to the second part of this Paper, in which it is proposed to describe some of the production methods employed and the administrative problems which were encountered in the manufacture of telephone apparatus at Mix and Genast in their Stuttgart factory.

PART II

A Glimpse at German Telephone Manufacturing Methods and Some Administrative Problems

The firm of Mix and Genast was founded in 1879 in Berlin. It is one of the oldest firms in the German telephone industry and is an associated company of the great Standard Electric Organisation and of the International Telephone and Telegraph Corporation of America. Like many other German factories, Mix and Genast suffered considerable loss as a result of the War, including a complete dismantling of its main works in Berlin by the Russians. When under the Allied occupation, Germany was divided into zones and especially on account of the uneasy situation in Berlin, the firm set up a second factory at Stuttgart in the south-west of the American zone. Some 3,000 persons are employed at the Stuttgart factory which consists of a group of eleven buildings taken over from the Heinkel Aircraft Company in 1946.

The Principal Problem

The principal problem encountered in telephone manufacture is that of co-ordination. It has already been indicated that the problem of the production administration departments increases with the complexity of the organisation. For example, in a machine shop with some fifty machines, each engaged in the continuous manufacture of one component week after week, administrative problems are relatively simple, being confined mainly to the provision of the raw material, inspection of the parts produced, maintenance of the tools and the delivery of the completed part. Under this type of organisation concentration can be centred almost entirely on the improvement of the process or method, layout, handling and so forth, and there would be a maximum return on invested capital with the minimum amount of trouble. On the other hand, if the same shop were required to produce 1,000 different components, each in turn requiring a number of separate operations to be carried out on different machines and utilising a wide variety of materials, the administrative problem becomes very difficult and far more complex. This is the condition which is found in the manufacture of telephones and the type of equipment encountered and some of the problems of production will now be briefly indicated.

The manufacturing departments are divided into four main groups:

(1) *The Machine Shop*

The main machine shop at the Mix and Genast factory is shown in Fig. 12. The shop layout is arranged for small batch production, that is to say, the machines are grouped according to their type and capacity. In Fig. 13 two heavy power driven friction screw presses are carrying out heavy forming operations on the yoke of a flat type relay. The total number of operations required on this detail alone is 37, and the part is one of nearly 10,000 various details which pass through the machine shop every month. In order to obtain economic runs, the batch size for each part must be carefully determined, and unauthorised departure from it by the shop supervision can result in the most unholy messes! While it will be agreed that sound economic machine loading is very necessary, it should not be overlooked that what often appears "economic" is far from being so when viewed as part of the whole programme. The effect of unsound economics can be observed by the planning of methods employing complicated and expensive tooling for parts which do not warrant such expenditure. For this reason, simple tools seem to be preferred, even where it would be an advantage to invest in more advanced tooling to assist in the subsequent assembly of the parts. Many instances of over-simplified press tools were found which resulted in a multiplicity of operations involving much handling of the parts between each operation. Where it had been found possible to arrange for these operations to be carried out on adjacent machines, as in the press shop, inter-operation handling was assisted by using a series of small portable motor driven canvas belt conveyors to transport parts from one press to the next.

Where the number of components required per week is relatively large, a number of remarkably ingenious tools has been designed. One example is the press tool developed for the production of the flat relay armatures. These were previously made in six press operations, followed by drilling and tapping operations. All these have been combined in a progressive tool designed to form, pierce and tap the

Fig. 12
General View of Telephone Machine Shop

armatures from a plain blank. The parts are stacked in a magazine and transfer-fed through the tool which carries out the piercing of four holes, three forming operations and a flattening operation, followed by the tapping of two holes on a tapping machine built on the end of the press tool and synchronised with the press.

The introduction of this new method for the production of relay armatures has reduced the total number of operations from 21 to 14, and the manufacturing time by nearly 70%. A saving of this magnitude will naturally have increased the production capacity correspondingly but, unlike a concern manufacturing consumer goods where as many articles can be sold as are made, the telephone manufacturer is usually faced with a restricted market. The introduction of special purpose tools and equipment is, therefore, found only on a very limited scale, in order to keep the various production departments sufficiently flexible to handle the very large variety of components required.

The great variety of components flowing through the production departments, therefore, raises a number of administrative problems, the greatest of which is how to get the right number of parts to the right places at the right time, which is the responsibility of the Production Control, the largest administrative department in the factory. This department

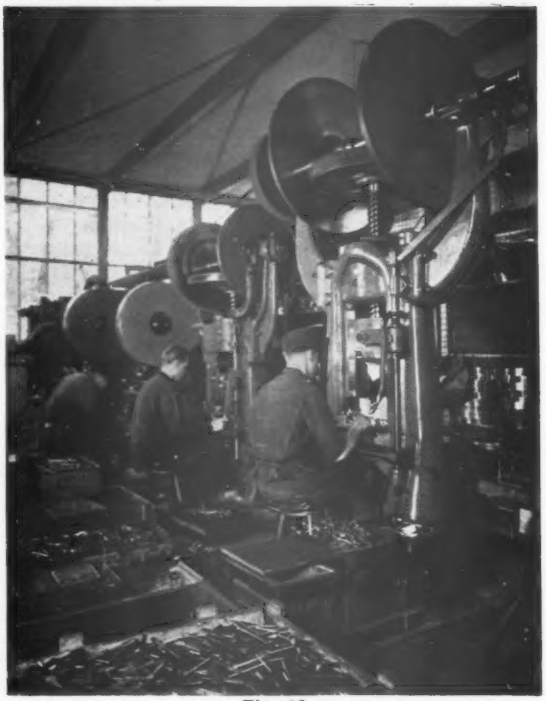

Fig. 13
Heavy Press Section

Fig. 14
Telephone Selector Assembly Lines

maintains very close co-operation with the production planning departments, which have undergone a complete revision since the end of the War. Formerly, the planning department was a centralised body in which the responsibility for the determination of the methods for the production of the individual details, assembly and testing of a particular piece of apparatus, was assigned to one man. As a result of the dispersal of the factory into a number of buildings, it was decided to divide all administrative departments into a number of separate units. Thus, the machine shop now has its own production control, planning and time study groups. Specialisation has become the policy of the Company and now each section of the machine shop, that is, press shop, milling, drilling, turning and sheet metal work, has its own planner who can concentrate his attention on the particular manufacturing methods for which he is responsible. The same situation exists in the other manufacturing groups, the second of which will now be described.

(2) *Apparatus Assembly Departments*

These departments are divided into three sections, each of which is concerned with the production of

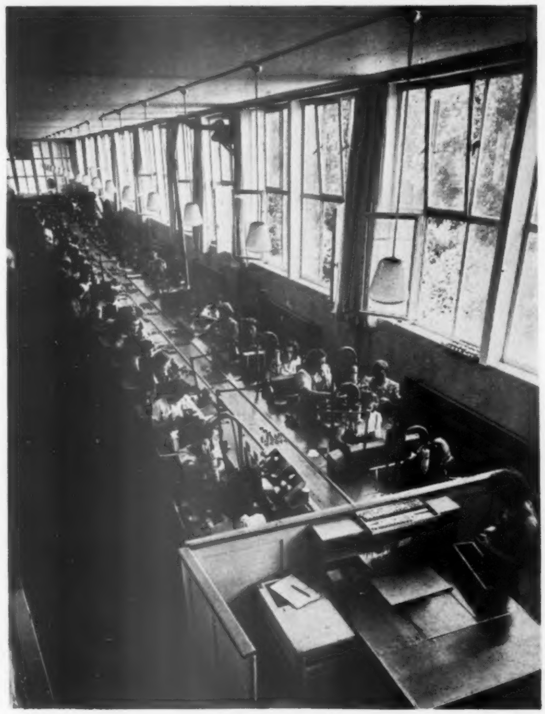

Fig. 15
Uniselector Assembly Line

a separate piece of apparatus, which can be seen in the following series of illustrations. The general arrangement of the assembly sections are on similar lines, and Fig. 14 shows the layout for the manufacture of the uniselector or step-by-step switch. These are built up on the flow line principle used throughout the assembly departments. The line shown in Fig. 15 is for uniselectors and is 65 ft. long. Operators sit at herringbone benching down the centre of which runs a conveyor belt. The assembly of the uniselector is broken down into a large number of operations, each of which is carried out by a separate operator. The planning of the assembly and the division of work is arranged by the planner responsible for the line and is based on information supplied by the time study department employing the R.E.F.A. system (referred to in Part I of this Paper), which have established times for each assembly element in the building-up of the apparatus. As the production requirements of the line rise and fall, the division of the assembly work is juggled so that the necessary time to carry out each of the separate operations, which includes the adjustment of the selector, is balanced to avoid overloading any one operator. With this system of working it is, therefore, of paramount importance that the time standards employed are right. For each production programme quantity required, a separate layout plan is used which is displayed at the head of each line. For example, where the required output is 275 pieces per week, the assembly is divided into thirty operations, and the allowed time for each is given as 1.845 minutes. To maintain an even tempo and to prevent a piling up of work along the line, a "feeder" places sets of parts on the conveyor at regular intervals from the feed store. It also is this person's job to provide each operator with a supply of other details from the store, such as screws, nuts and washers which are issued in bulk quantities and not fed down the conveyor.

The assembled uniselector can be seen in Fig. 17 which is a 3-level, 11-point switch, and Fig. 18 shows the largest type which has 10 levels and 17 points. There is a variety of codes, each of which has a different number of levels, single or double ended wipers or variations in the pile up of contact springs. The test sets used during the manufacture of these switches is universal and is designed to function automatically.

The sets work on a punched card principle, derived from the Hollerith punched card system. In this case, the punched card is a thin brass plate which has a pattern of holes pierced in it corresponding to the code number of the apparatus to be tested. When the plate is inserted in the test set, the holes in the plate determine the test conditions

Fig. 16
Two-Motion Selector Assembly Line

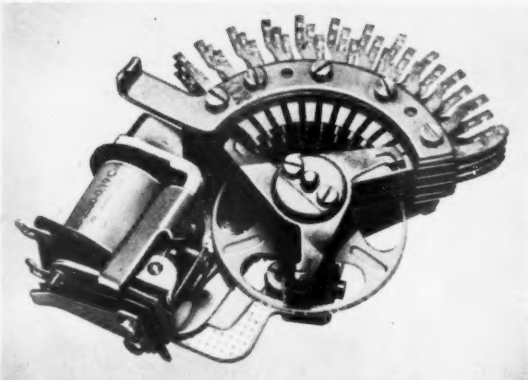

Fig. 17
11-Point Uniselector

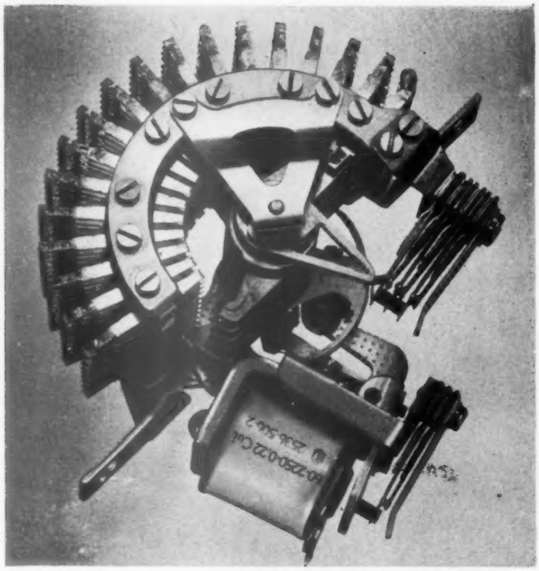

Fig. 18
17-Point Uniselector

required. The apparatus is connected to the test set and such functions as breakdown voltage test, short circuits, failures of contact springs to make or break connection, resistance of coils, etc., are carried out systematically.

An illuminated display panel indicates when the test is completed and shows any defect.

These test sets have the advantage over earlier testing methods in that they remove the possibility of human error and save labour. A large number of these automatic testing sets are to be found in the various departments, but one of the biggest problems in the manufacture of the apparatus is that of improving methods of adjustment, and in this sphere the problem is that associated with the adjustment of contact springs, illustrated in Fig. 19.

The relay is one of the most important pieces of apparatus in telephone equipment and is required in the largest quantities. For this reason a separate department has been set up for relay manufacture which is divided into three main groups: the winding of the coils, assembly of springs and armature to the coil, and the adjustment.

As in the case of assembly of the uniselector, the flow line principle is used for the building up of the relays and part of the herringbone bench and the belt conveyor can be seen in Fig. 20 where the operator is dressing the tips of the springs before adjusting. The adjusting is one of the most labour consuming operations in the mechanical assembly departments and demands the employment of carefully trained personnel. There has been a great concentration of effort on the part of the planning

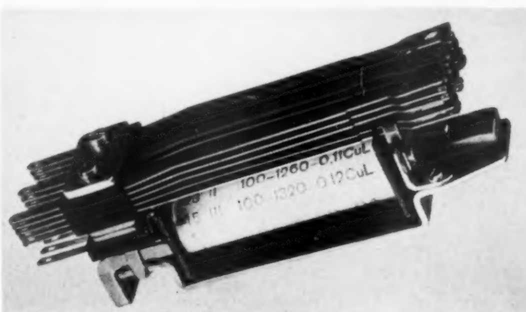

Fig. 19
Flat Type Relay

Fig. 20
Twinning Relay Contacts

Fig. 21
Adjusting Relay Spring Tension

and methods improvement departments to simplify the adjusting and to assist the operators engaged on this exacting work. Some success has been achieved by arranging for the springs to be formed before assembly into the pile-up in such a manner that they exert a pressure in a certain direction which is in excess of the tension required. The excess pressure is then removed by bending the spring at its root

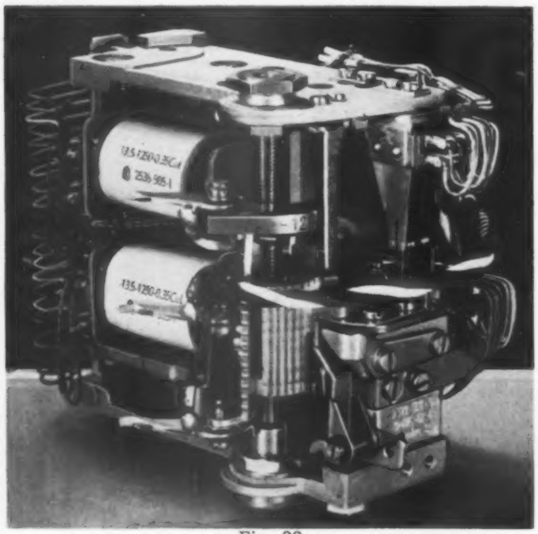

Fig. 22
Two-Motion Selector (without Contact Bank)

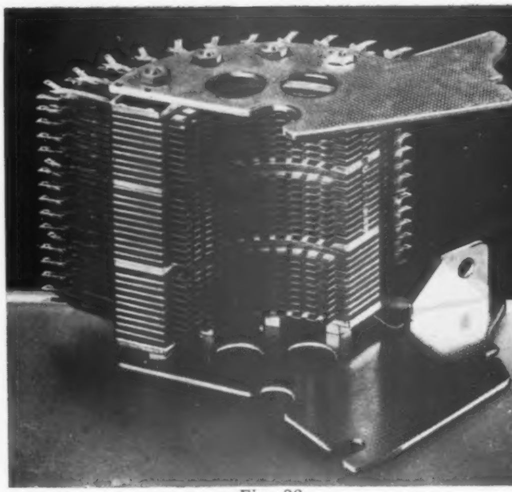

Fig. 23
Selector Contact Bank

until the required tension is read on the gauge held in the right hand of the adjustor shown in Fig. 21. The requirements of the adjusted relay are so critical that attempts to eliminate the tensioning of springs by hand have not been successful, but the introduction of over-tensioned springs is claimed to have raised the output per operator from 800 to more than 1,000 springs per day.

The most complicated single piece of telephone apparatus is the selector or two-motion switch shown in Fig. 22. This selector has been used in German telephone equipment since 1927. It is similar in operation to the model used by the British Post Office, but is more compact and requires only half the space in a telephone rack of its British counterpart. Due to its compactness, however, it is more difficult to service than the British model. The complete selector consists of an electric magnetic operated switch and a contact bank, Fig. 23. The complete assembly is shown in Fig. 24. The main frame of the switch is an aluminium alloy diecasting and the method of machining the important surfaces of this

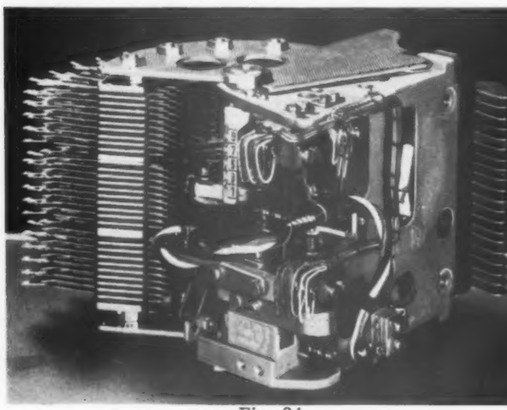

Fig. 24
Assembled Two-Motion Selector and Bank

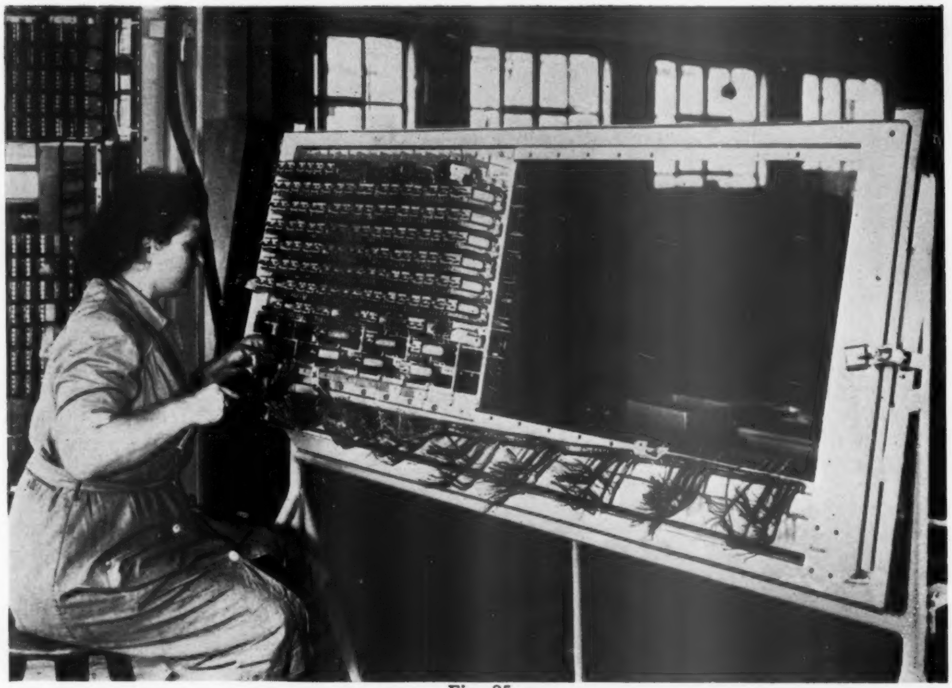

Fig. 25
Wiring a Relay Rack

detail has been the subject of a recent methods investigation. Complete interchangeability between the switch parts and the contact bank is demanded. A special purpose milling machine which machines eight working surfaces at one setting was developed in order to obtain the necessary accuracy.

The economics of the new method of machining have been strongly criticised because the machine is not fully loaded, explaining of course that if orders could be increased up to a certain figure then a "saving" would result. The maintenance of accuracy and the reduction of scrap are often held to be less tangible savings than the direct savings in machine man hours, but where methods improvement or production rationalisation is based on accurate cost analysis, the criticism is not always justified.

The liaison which exists between the production planning, shop supervision, methods engineering and time study departments were noticeably closer in the decentralised set-up indicated earlier, where the individuals responsible for these administrative functions work together in a small office adjacent to the factory department for which they are responsible, and it was felt that their approach to the every-day problems on the shop floor were dealt with in closer co-operation and their decisions less tempered by inter-departmental politics.

The third manufacturing group is the department in which the three telephone components shown in the last series of illustrations come together for mounting in frameworks and cabinets which make up telephone exchange equipment.

(3) *The Wiring Shop*

This department is the focal point in the co-ordination of all phases of manufacture and here is reflected the efficiency of the whole production organisation. The work activities of this manufacturing group can be divided into four phases:

(1) Mechanical assembly of components into frameworks or cabinets.
(2) Making up of the cable forms.
(3) Wiring and soldering of the mounted components.
(4) Inspection and testing of the equipment.

A typical relay rack, though not fully equipped, is shown during the wiring-up operation in Fig. 25. The rack is a rectangular iron framework and is mounted sideways on a light tubular steel structure which is used as a jig during the assembly of the relays and subsequent wiring operations. The jig is fitted with castors and serves to transport the rack through the assembly and wiring shop. It is the practice to work with the equipment racks in the horizontal position shown, which allows the operators to work seated or standing with equal comfort.

The most common problem met with in the production of telephone equipment is that of wiring together the vast conglomeration of apparatus which makes up the complete telephone exchange. Hundreds of millions of wired connections have to be made annually and the apparently minor operation of soldering a wire on to a tab assumes astronomical magnitude because of the number of times it has to be performed. A typical cable form can be seen

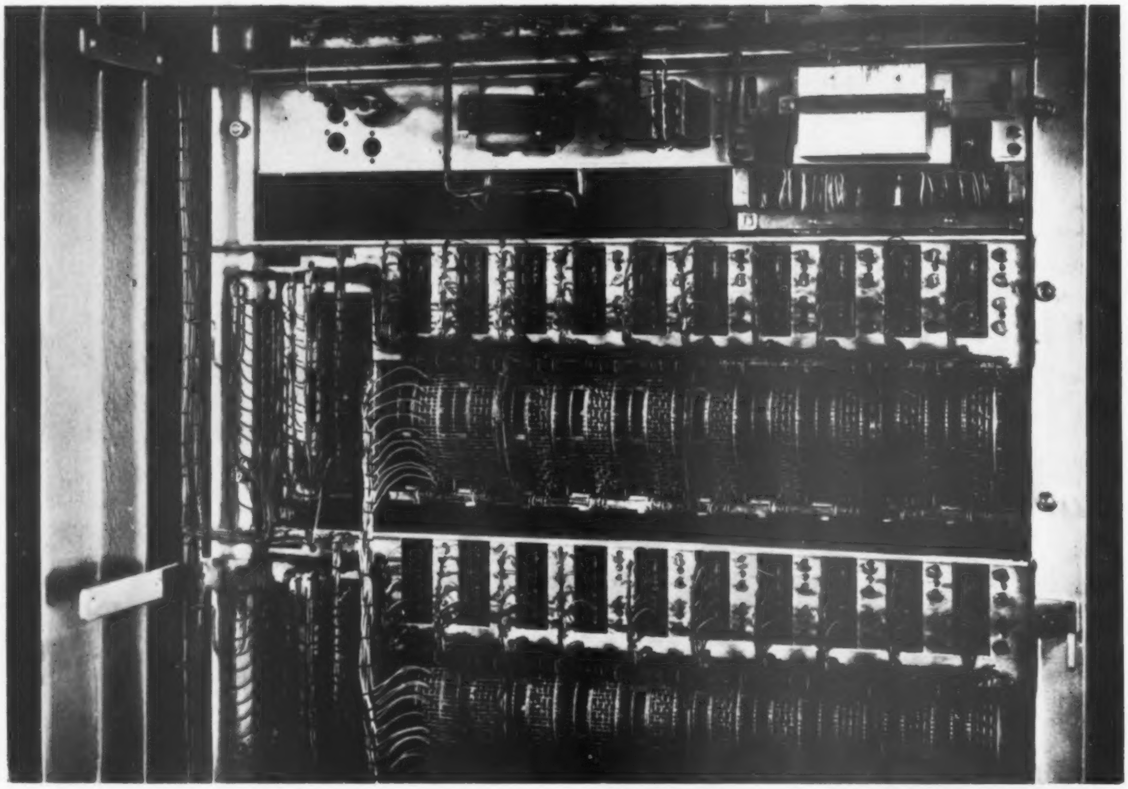

Fig. 26
Part of a Wired Uniselector Rack

along the side of the framework in Fig. 25, and further examples are shown in Figs. 26 and 27. These cables are made up to the required form on wooden boards upon which the pattern is drawn out and the wires are laid between pins driven into the board. The main stem and branches of the finished cable are laced firmly to keep the wires in place, the ends of wires are cut to the required length and the insulation removed in preparation for the actual wiring and soldering operations. In Fig. 27 is shown a part of a rack of two motion selectors. This photograph shows a rear view of the selector bank and the method of cabling employed.

For this piece of apparatus a ribbon cable is used which runs the length of the rack and lies in the space between adjacent tags. This makes the soldering of the joints more accessible and for this equipment a multi-point soldering iron has been introduced. The soldering iron bit embraces five tags simultaneously and five wires of resin-cored solder are fed to the iron through feed rollers.

Due to the success so far achieved with this multi-soldering method, serious consideration is now being given by the telephone equipment engineers to the more general application of the ribbon type cable in the wiring of uniselectors, not only because it gives greater accessibility for soldering but also because

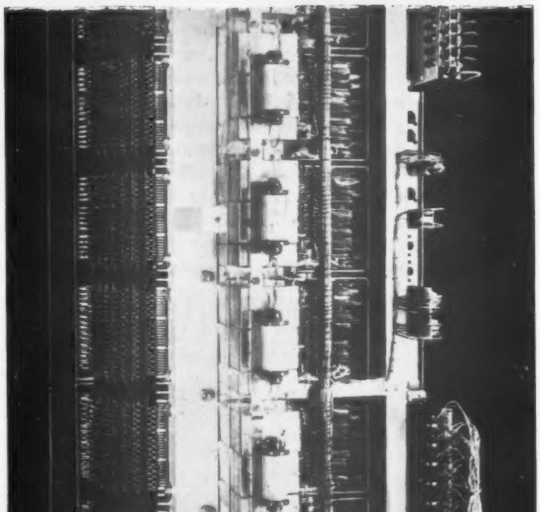

Fig. 27
Selector Rack showing Ribbon Cable

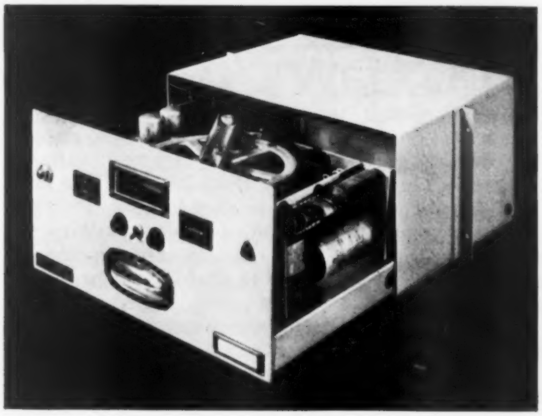
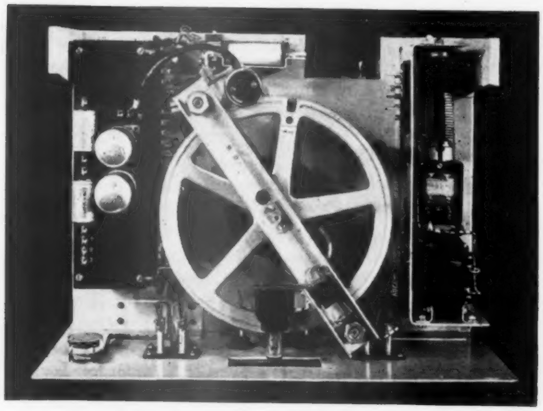

Fig. 28
Magnetic Tape Telephone Exchange Announcer

it has been found to be cheaper than the more conventional cable-form.

(4) *Special Equipment and Systems Department*

The manufacturing programme of the Company embraces an extremely wide range of communication equipment in addition to the general conception of telephone apparatus. These include radio link, telegraph transmission systems, fire alarm systems, railway signalling, and a host of other special systems which can be built up using telephone apparatus.

The work of this department, although similar in nature to that of the previous two groups is run on a jobbing shop basis. Orders are usually small and a "one-off" job is most common. Here, then, can be seen how the administrative problems vary throughout the organisation and that the production and administrative methods which produce successful results in one department may have disastrous results in another. In view of this, much can be said in favour of the decentralisation of management functions operating under a co-ordinative group at a higher level.

As an example of one of the many special pieces of equipment which are manufactured in this group of departments, I have selected a device which is among the latest developed by the Company. This is the automatic Telephone Exchange Announcer. This ingenious device consists basically of a magnetic tape recorder and a general view of its construction can be seen in Fig. 28. The spoked wheel in the centre carries on its circumference a magnetic tape upon which the telephone operator's voice has been recorded. On the right of this is the power pack which feeds the amplifier on the left, which amplifies the signal picked up by the playback head. Fig. 29 shows the apparatus mounted in the firm's own telephone exchange. The output from the amplifier is fed to the telephone handset instead of the usual dialling-tone so that when the receiver is lifted, a voice repeatedly announces the name of the exchange to which the subscriber is connected. When a subscriber on a different exchange is required, a code number is dialled and a similar apparatus announces the called exchange. Thus the possibility of calling a number on the wrong exchange is eliminated, since the caller can hear if he is connected to the desired exchange.

So far this device is only installed in small private exchanges not under the administration of the German Post Office, but application has been ex-

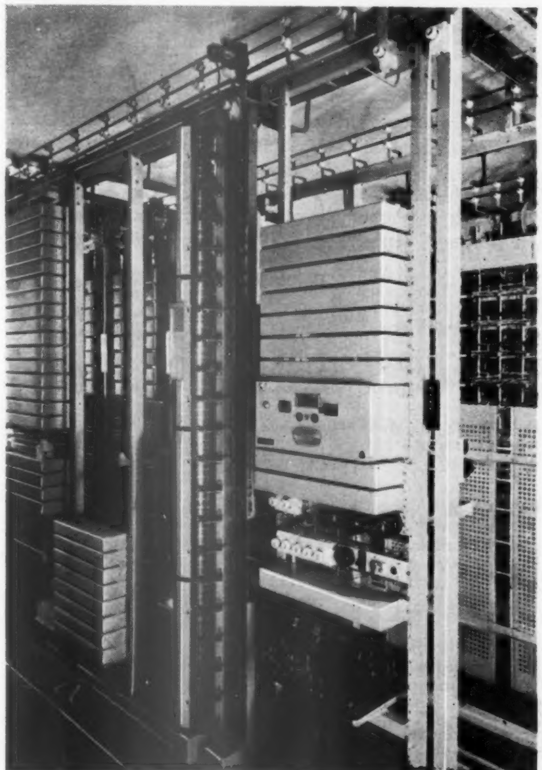

Fig. 29
Magnetic Announcer Mounted in an Exchange

tended in other fields, and the German Railways have recently placed an order for a large number of these magnetic tape announcers to extend their train despatching systems.

Some Comments on Germany's "Potential Production Energy"

The reconstruction of bombed cities is only one of the many economic and social problems which thwart the lives of the post-war Germans. They are a defeated nation from a military point of view, and the individual as well as the nation has suffered tremendous material losses. Apart from industry, which was crippled by the war, almost a quarter of the dwellings in the now German Federal Republic were destroyed. How then is it possible for a defeated nation, frustrated by the occupation of the Allies, to have made such a remarkable and rapid recovery?

Taking Western Germany as a whole, industrial production for 1952 was 167% of the 1936 level, and the value of production almost twice as high as it was in 1948. The underlying strength of Germany's economy is no longer in doubt. Hitler's government, the prostration before false gods, the dissipation of man-power and of skill, bombing, dismantling of industrial plants, inflation and even disillusionment, have failed to destroy it.

I found it difficult to find the formula for their success and indeed the more I learned about what the Germans thought and felt, the more convinced I became that they had further to go in the solution of their industrial and social problems than we have.

The successful working of a productive unit depends very largely on the desire of its members to work together towards a common goal. This desire has been translated into action and the answer to Germany's rapid productive progress can be summed up in two words: "Hard Work". The attitude towards work on both sides of industry I regard as simply an attitude of mind. Just what has brought about this attitude of mind is a very complex subject, and it would take too long to deal with it here, but briefly it seems to be a deep seated national characteristic which has been cultivated in the soil of their past economic and social conditions.

German's greater rise in productivity compared with Britain is the result of longer working hours and a more acute consciousness of the need to produce. We cannot afford to ignore these points, or the reality of Germany's recovery. The right way to meet the challenge is not by grumbling about it, nor is it necessary to cut wages or increase the standard hours of working, but we must increase our productive efficiency to counter-balance their lower wages and longer hours. How our productive efficiency can be raised is not the subject of this Paper, and, indeed, many of the ideas and solutions applied to problems in Switzerland or Germany are not good or worthwhile applying, and many doubts and fears were expressed by both men and managers about their own unsolved production problems.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers. (This list was compiled for press on 19th October, 1953.)

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LONDON GRADUATE SECTION WEEKEND SCHOOL, 1953

The annual Week-end School of the London Graduate Section has now become a firmly established event. On the week-end of September 12th and 13th, the Fourth School met to consider "Work Study", in the pleasant surroundings of the Beatrice Webb House and Estate, near Dorking, in Surrey.

Although the School proper did not commence until 2 p.m. on Saturday, about a dozen of the thirty participants arrived on Friday evening, the intervening time being absorbed by social activities for which the venue caters so well. Mr. W. F. S. Woodford, Secretary of the Institution, in a chat to members during the week-end, stressed the value and pleasure to be derived from informal contacts between members, officers of the Institution and lecturers.

The School was ably chaired by Mr. R. E. Leakey, President of the London Senior Section, and an excellent summing-up was presented by Mr. H. P. Jost.

The lecturers were set a difficult task, inasmuch as the Section had asked them not to deal with the technical aspects of work study itself, but rather to concentrate on the managerial aspects of the subject. This course was adopted because it was felt that whilst copious technical literature was available, there was a relative dearth of material dealing with the managerial considerations of work study.

Mr. A. R. Mann, of the U.K. Production Study Department of Unilever, Ltd., set the tempo of the week-end very well with his first lecture. He dealt with the organisational aspects of the Work Study Department, both internally and with respect to the rest of an undertaking, and went on to consider problems of co-ordination, communications and training.

This lecture promoted a very lively discussion, the highlight of which centred on whether or not the Work Study Department operated in an advisory or executive capacity. The interesting thought eventually emerged that even if the department did act in an advisory capacity, its advice could conceivably become so consistently reliable that from the management's point of view it became an executive function.

The second lecture was delivered by Mr. J. E. Payne, of Production Engineering, Ltd. He put the cardinal feature of successful work study before the school—good human relations. He examined the various motivations leading to the co-operation or resistance of individuals working in various capacities, and also of groups of people. Amongst many other matters, the ensuing discussion embraced the problem of selling ideas. One novel approach was for the "seller" to offer two solutions of a problem being tackled, one the true solution, the other being obviously wrong. In cheerfully rejecting the wrong solution, the person who is difficult to "sell" will more easily accept the correct one.

The third lecture, by Mr. R. B. Kemball-Cook, also of Production Engineering, Ltd., gave a comprehensive survey of the ways by which work study can help management. As might be expected, the lecture and discussion covered a broad field, and it is difficult to single out specific features without detracting from the merit of the whole. However, the School found no difficulty in agreeing two thoughts for British management: first, that an incentive wages scheme is no substitute for good management; and, second, that as production methods improve and direct labour hours fall, the application of work study in indirect production and staff departments becomes of importance for reduced costs.

Following the discussion, Mr. Kemball-Cook showed a film illustrating an improvement in work methods made in a hosiery mill, together with an application of three-dimensional models to a plant layout problem in the textile industry.

The School closed with a vote of thanks to all those who had contributed to the success of the week-end, particularly those who had worked "behind the scenes".

As in past years, the School provided an excellent opportunity for members to advance their ideas and possibly make their first incursion into the art of public speaking.

L. J. S.

NEWS OF MEMBERS

MR. C. METCALFE

Mr. C. Metcalfe

Mr. C. Metcalfe, Associate Member, has been appointed Managing Director of E.M.I. Engineering Development Ltd.

Mr. Metcalfe received his engineering training at a well-known firm in the North of England and was subsequently employed as a Design Engineer in the Engine Division of The Bristol Aeroplane Company.

Joining the Gramophone Company as an Engineer in 1930, he has since been associated with companies in the E.M.I. Group.

During 1935 he was appointed Chief Draughtsman of the Design Section in the Production Engineering Division and from 1938 has collaborated in the design of the E.M.I. Companies' domestic products.

During the war years he was an Executive Engineer in the team responsible for the design of important Government projects.

In May, 1946, Mr. Metcalfe was appointed a Director of E.M.I. Engineering Development Ltd.

MR. F. W. ROSS

Mr. F. W. Ross, Member, a member of the Cornwall Section Committee, has now resumed his duties at the Cornwall Technical College, having recovered from his recent illness. Mr. Ross would like to take this opportunity of thanking his many friends for the good wishes and sympathetic messages he received during the time he was indisposed.

COLONEL R. W. W. TAYLOR

H.M. The Queen has approved the appointment of Colonel R. W. W. Taylor, T.D., Member, as Honorary Colonel of 120 Transport Column, R.A.S.C. (T.A.).

Col. R. W. W. Taylor

Colonel Taylor has served with this unit since 1935 and during the War, when he served all over the Middle East and Western Desert.

Well-known in Midland industrial circles Colonel Taylor is the Chairman and Managing Director of Lang Pneumatic Ltd., Wolverhampton.

MR. H. UNSWORTH

Mr. H. Unsworth, Member, has resigned his appointment with Accles & Pollock Ltd., and has joined Lockheed Hydraulic Brake Ltd., as Deputy General Works Manager.

Mr. Unsworth is a member of the Institution's Materials Handling Sub-Committee.

MR. R. H. VARCOE

Mr. R. H. Varcoe, Associate Member, has been appointed Managing Director of his firm, Preminco Ltd., formerly Premier Industrial Consultants, Harrow.

MR. J. P. FORD

Mr. J. P. Ford, Associate Member, has been appointed Managing Director of Associated British Oil Engines (Export) Ltd. He is also Managing Director of Brush Export Ltd., and National Oil Engines (Export) Ltd.

MR. C. H. BACON

Mr. C. H. Bacon, Member, has recently been appointed Managing Director of his firm, Sangamo Weston Ltd., Enfield.

MR. W. R. CHILDS

Mr. W. R. Childs, Associate Member, has recently been appointed a Director of the Monitor Engineering and Oil Appliances Co., Birmingham.

NEW APPOINTMENTS

Mr. W. Adams, Associate Member, has been appointed Works Manager of his Company, Sangamo Weston Ltd., Enfield.

Mr. E. W. Beever, Associate Member, has taken an appointment with Euclid (Great Britain) Ltd., Lanarkshire, as Industrial Engineer.

Mr. P. Chambers, Associate Member, is now a Production Engineer in the Switchgear Development Department of The English Electric Co. Ltd., Stafford.

Mr. T. J. Davies, Associate Member, has relinquished his post as Lecturer at the Glamorgan Technical College, Treforest, in order to take up duties as Head of the Engineering and Mining Department of the Rhondda Technical Institute.

Mr. P. R. Hosken, Associate Member, has relinquished his post in the Technical Office of the Pneumatic Toolworks of Holman Brothers Ltd., in order to join the teaching staff of the Cornwall Technical College.

Mr. A. J. Lund, Member, has resigned his position as General Manager of Cooper Engineering Ltd., and has now joined Simpson & Co. Ltd., Madras, as General Manager.

Mr. C. Unwin Portsmouth, Associate Member, has recently taken up an appointment as Manager of the Department of Defence, Canadian Radio Manufacturing Corporation, Toronto.

Mr. E. F. Priest, Associate Member, has been appointed Manager of the Engine Division, Field Aircraft Services Ltd., Croydon.

Mr. R. S. Russell, Associate Member, has taken the position of Production Engineer with Crudens Ltd., Misselburgh.

Mr. J. Shilkin, Associate, has been appointed Deputy Director, Inspection Service, Army Branch, Department of Supply, Australia.

Mr. W. L. Soul, Associate Member, has been promoted to the position of Chief Draughtsman with his Company, The Hoffmann Manufacturing Co. Ltd., Chelmsford.

Mr. C. C. Spanswick, Associate Member, has relinquished his post as Lecturer at the Cumberland Technical College and has been appointed Lecturer in Production Engineering at the Brighton Technical College.

Mr. C. Taylor-Cook, Associate Member, is now Principal of the Poplar Technical College, London, E.14.

Mr. A. E. Watkiss, Associate Member, has accepted an appointment as full-time Lecturer in Production Engineering at the Derby Technical College.

Mr. J. P. Welburn, Associate Member, has taken the position of Assistant (Grade "B") at the Hull

Municipal Technical College with special reference to Production Engineering Development.

Mr. C. T. Wheatcroft, Associate Member, has relinquished his post with British Insulated Callenders Cables Ltd., and is now a Sales Engineer (Industrial) with the Vacuum Oil Co. Ltd., and is responsible for the Nottinghamshire and part of Derbyshire area.

Mr. R. J. C. Whitaker, Associate Member, has been appointed Chief Production Engineer of The Glacier Metal Company's No. 1 Factory at Alperton.

Mr. S. Worne, Member, a former Director of Chandos Engineering Co. Ltd., Egham, Surrey, has purchased the goodwill and furnishings of that Company, and is continuing in business from the same address with the same lines of manufacture.

Mr. C. R. Basu, Graduate, is now employed by the Government of West Bengal as an Inspector of Boilers.

Mr. D. O. Boden, Graduate, is Assistant Lecturer, Grade "B", at the Chesterfield College of Technology, not Grade "A", as reported in last month's Journal.

Mr. O. S. Brown, Graduate, is now a Technical Representative with Machine Shop Equipment Ltd., London.

Mr. H. Calderbank, Graduate, has taken up an appointment as Assistant Grade "A" at the Bolton Municipal Technical College.

Mr. A. E. Clauson, Graduate, has taken a post as Designer with Geometric Designs Ltd., London.

Mr. L. Edmonds, Graduate, has been promoted to Section Leader in the Engineering Design Office at The General Electric Company's Research Laboratories, Stanmore, Middx.

Mr. L. H. Janes, Graduate, has been promoted to the position of Chief Draughtsman of A. Johnson & Co. (London) Ltd.

Mr. K. Macdonald, Graduate, has taken up an appointment as Work Study Engineer with Paton & Baldwin Ltd., Darlington.

Mr. P. A. Taylor, Graduate, is now Senior Time and Motion Study Engineer with The English Numbering Machine Co. Ltd., Enfield.

Mr. R. J. Temple, Graduate, is holding the appointment of Assistant Production Manager with Limit Engineering Ltd., Islington.

Mr. E. G. Woodhall, Graduate, has been appointed Assistant Works Manager of Ewarts Ltd., Dudley.

HAZLETON MEMORIAL LIBRARY

Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. The full facilities will not be available at the following times during this month :—

Tuesday,	3rd November	from 2 p.m.
Thursday,	12th November	all day.
Tuesday,	24th November	from 2 p.m.

It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when ordering books.

REVIEWS

338.9 PRODUCTIVITY

Measurement of Productivity: Methods used by the Bureau of Labour Statistics in the U.S.A. Organisation for European Economic Co-operation, Paris —Technical Assistance Missions Nos. 7-10-11. *Paris, O.E.E.C.,* 1952. 104 *pages.* 4s. 6d.

This report is the result of an investigation by a group of representatives of industrial research associations, government departments and universities from all the European countries including Britain.

The object of the mission was to study the working of the existing Productivity Division of the American Bureau of Labour Statistics. It is interesting to note that the Productivity and Technological Development Section of the American B.L.S., whose main responsibility it is to produce productivity statistics, employs a staff of 50/60 people in Washington and about 10 agents in the various Regional Bureaux. One of the main tasks of this Government service to industry is to co-ordinate all the statistical work done by the Government Departments with a view to reducing the cost of surveys, avoiding duplication, and standardising questionnaires and methods of classification, sample survey techniques, etc.

These productivity studies undertaken by the B.L.S. were first introduced in 1898, when unemployment created interest in the question of replacement of manpower by machine, and they came under the heading of "Labour Displacement by Mechanisation". Again, in 1925, technical progress in the U.S.A. had brought about a serious degree of technological unemployment and to counteract a feeling developing amongst workers' organisations that the workers were not getting their due share of the profits of technical progress, they wished to know just how great the progress had been. This relationship between wages and productivity was considered to be the most important aspect. The report goes on to say that fresh developments occurred at the end of the War, and that progress in U.S.A. productivity during the War had become a decisive factor in connection with wage claims put forward by the Unions who strongly support these productivity studies.

One section of the book is devoted to basic definitions of productivity and productivity measurement. Information regarding the method of carrying out the surveys, the publication of the results, and the use made of these reports is given in great detail. The appendix to the reports lists industries in which such

surveys are standard practice, and quotes actual examples of the method used to collect and compile the information gained from personal interviews and investigations by the B.L.S. agents in conjunction with and inside industry.

The value of this report lies in the fact that it is an unbiased comprehensive review of the activities of the Bureau of Labour Statistics in the field of productivity measurement. B.H.D.

621.791 WELDING

"Weld Design" by H. D. Churchill and J. B. Austin. *New York, Prentice Hall,* 1949. 216 *pages. Illustrated. Diagrams.* £2. 12s. 0d.

This publication deals with the process of welding in all its aspects. It covers both the elementary and the more advanced types of welding and, will, therefore, be of interest to students throughout the whole range of their studies.

Chapter 3 on "Stress Analysis and Design Data" is of considerable interest. The information contained in this chapter should assist in the design of all kinds of structures, and it gives details regarding rigidity and strength of the structures when complete.

Chapter 9, dealing with flame-cutting, is worthy of note. Although this process is well-known, it can be referred to for the latest practice. Flame-hardening is a subject on which there is great difference of opinion; this is dealt with adequately in this chapter.

Although Chapter 10 does not deal strictly with welding, the metal bending is a closely allied process, and correct preparatory technique will undobtedly make many welded components structurally superior.

The publication is recommended to all who are seeking information in up-to-date welding processes. H.A.C.

"Welding Practice", ed. by E. Fuchs and H. Bradley. *Butterworth's Scientific Publications in association with Imperial Chemical Industries Ltd.,* 1951-2. 3 *vols.* 511 *pages.* £2. 15s. 0d.

These books have been written by the Welding Panel of the Imperial Chemical Industries Ltd., which includes many well-known men in the field of metallurgy and welding. The books were originally written in booklet form for the guidance of engineers within their own organisations. They are intended as a work of reference for designers and engineers, particularly those connected with the chemical industry.

The work is so wide in its scope that it has only been possible to discuss briefly the major points. However, the more important references relating to each section have been listed to enable the reader to make a more detailed study.

The first volume consists of five chapters each dealing with an important section of the welding field, welding processes, metallurgy of welding, examination and testing, shop layout and finally welfare. The second and third volumes deal with the major aspects of welding ferrous alloys and non-ferrous metals and alloys respectively. Each section has been well illustrated with practical examples which will help engineers avoid design pitfalls, particularly in the chemical and pressure vessel industries.

The books can be recommended to those wishing to gain an understanding of welding technology without making a detailed study. G.C.S.

338.91 INDUSTRIAL PRODUCTION

"Industrial Frustration: Commonsense for Trade Unionists," by Lewis Craven Ord. London, *Mayflower Publishing Co. Ltd.,* 1953. 178 *pages.* 12s. 6d.

"Industrial Frustration" makes a fitting end to a lifetime's study of production technique.

L. C. Ord has left behind him a series of works on production which have changed in tone with growing experience, and perhaps a growing frustration of his inability to see within his own lifetime the achievement by British industry for which he has so long striven.

In this sense, "Industrial Frustration" is a measure of his own difficulties, and in it much of his previous practical background gives way to his personal ideals.

Over the years, L. C. Ord has set out to compare American and British industry, taking to task in turn both management and employee, and now, arising out of his own frustration, turns to the trade unions as the responsible party.

It is when we come to examine in more detail "Who is responsible for what" that this book becomes a little unreal. Those who have studied through L. C. Ord the American yardstick of productivity over the last thirty years may be forgiven if, with this last book, they should question not so much what is wrong with British industry, but the American yardstick with which it is measured.

It may be that L. C. Ord's self-confessed failure to establish British production on the level with American production, even under conditions where American production methods are used, lies in a deep-rooted aversion, not to American methods, but to the American way of life, if to achieve it means sacrificing those characteristics which we British people hold dear.

"Maybe", but in any case this is a book which should enable the reader to make up his mind.

To the student, to the idealist, to the management that can take some comfort out of the failure of others, this is a book to be read with relish.

To the practical 'doer' of the moment, this book will not have so great an appeal; idealism such as L. C. Ord's will need many lifetimes to bear fruit. R.C.M.

681.2 INSTRUMENTS

"Instrument Manual" ed. by J. T. Miller. 2nd ed. *United Trade Press Ltd., London,* 1953. 733 *pages, illus., diags.* £4. 4s. 0d.

This book is divided into 25 chapters, each of which is devoted to one particular class of instrument. These are too numerous to mention in detail, but every aspect of instrumentation appears to be covered.

Each chapter is complete in itself and contains a brief list of contents, a survey of the principles of the instruments in the class, together with illustrations of contemporary instruments, and is completed by a list of relevant British Standard Specifications, a list of text books, a list of references to articles in the technical press, and a buyers' guide.

In the introduction it is stated that the editor was faced with the difficult task of deciding what to leave out. In view of the wide scope of the instrument industry, this admission is not unexpected. In general, the selection of material appears to be reasonable and errors are scarce.

This book could be usefully employed in many types of establishments and in this connection, the buyers' guide could be particularly useful. This is a reference book and not a text book, and might well serve as a guide to a Production Engineer responsible for the selection and supervision of instrument installations of types of which he may not have expert knowledge.

It should be noted that this is a British publication and is based on British instruments. S.R.S.

OTHER ADDITIONS

791.4 FILMS

Great Britain—*Central Film Library.* **"Catalogue of Films for Industry.** *London, the Library,* 1953. 48 *pages.*

914.2 GREAT BRITAIN—Directories

M.M. Yearbook 1953: **A Comprehensive Guide to Sources of Supply of New and Second-hand Machinery of British and Foreign Origin.** *London, Machinery Market Ltd.,* 1953. 816 *pages.* 15/-.

331.81 HOURS OF WORK

Cotton Board Conference, St. Annes-on-Sea, 1953. **"Papers prepared for the . . . Conference on Double Day Shift Working in the Cotton Industry."** *Manchester, The Board,* 1953. 50 *pages.*

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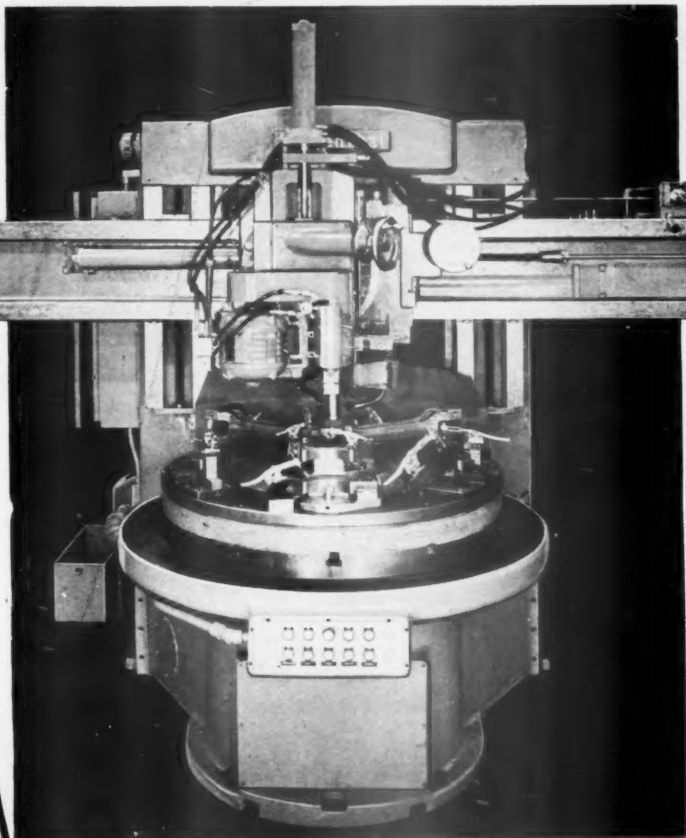

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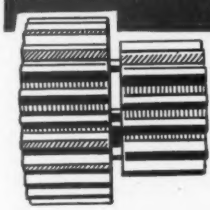

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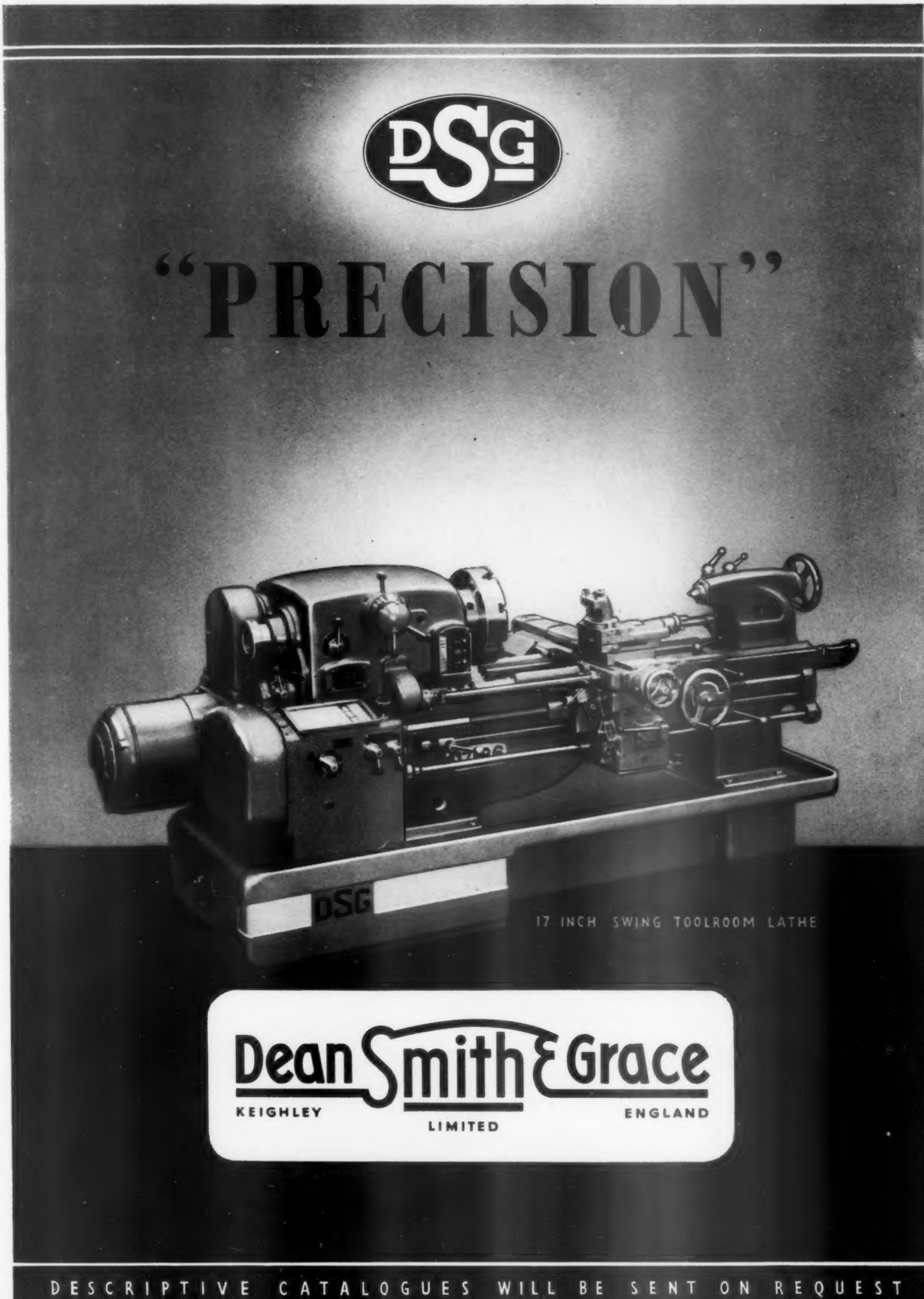

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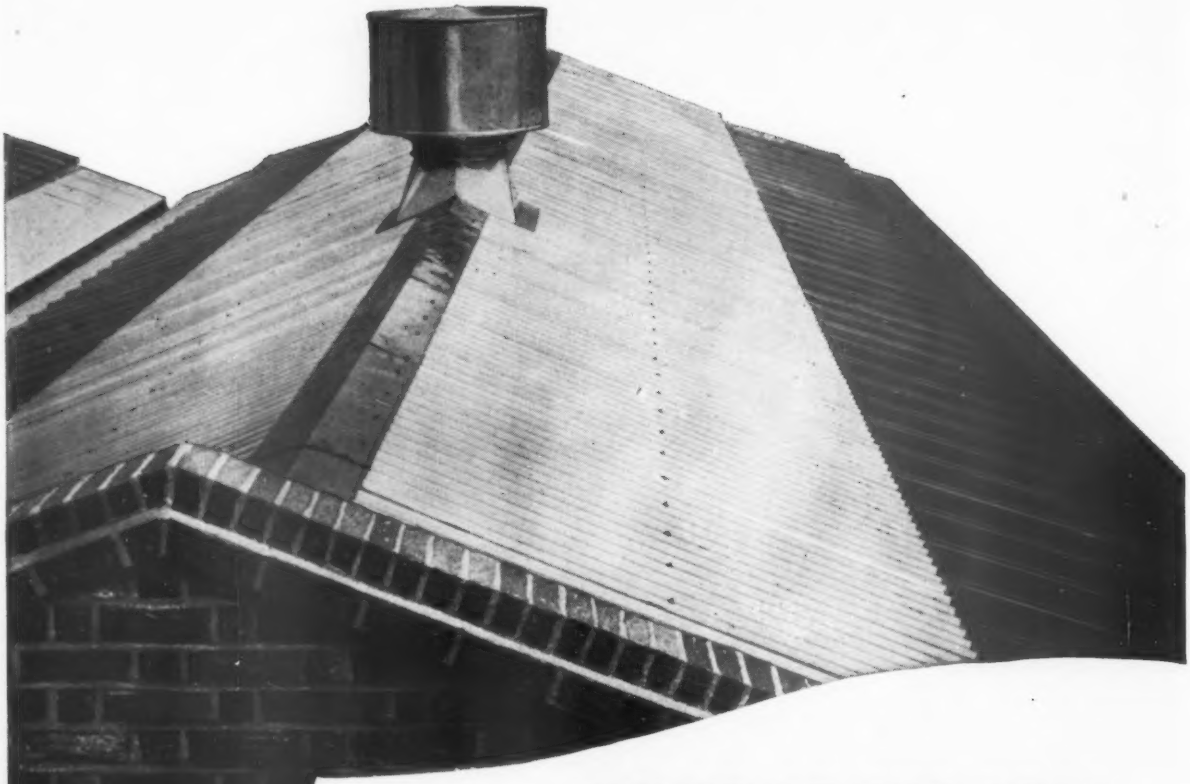

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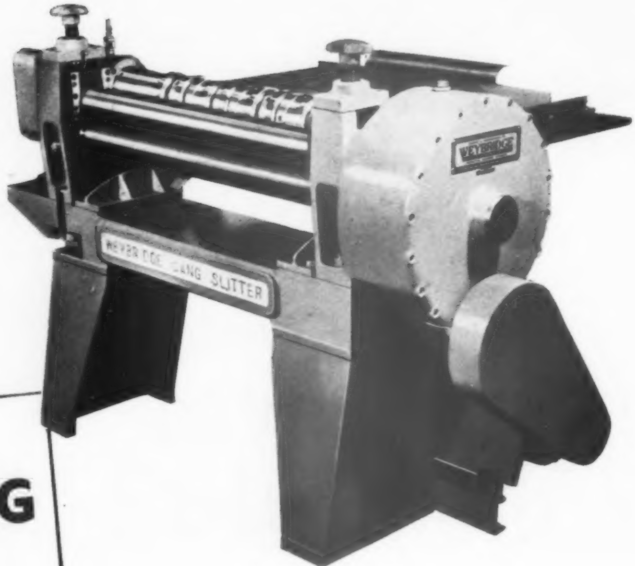

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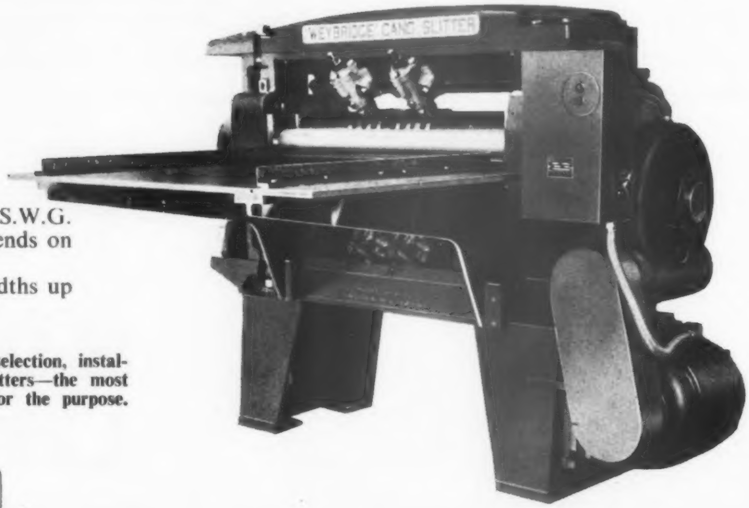

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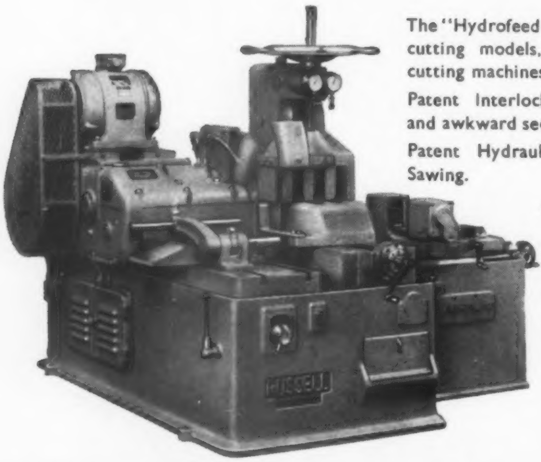

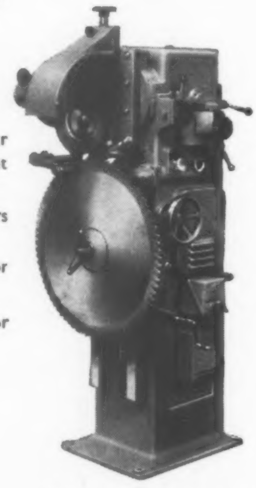

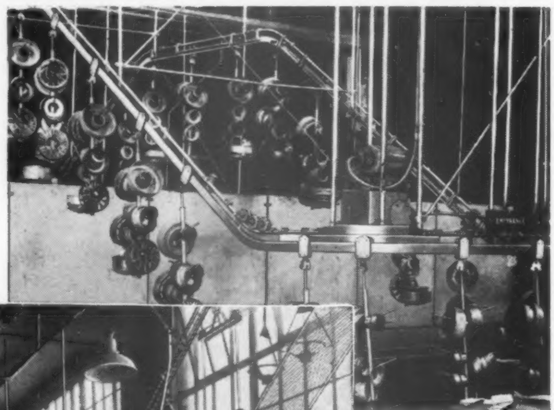

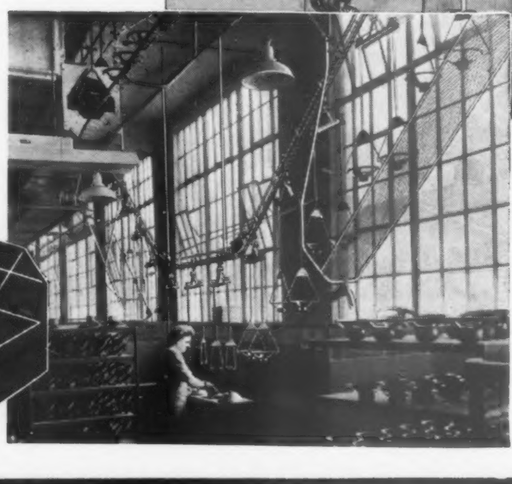

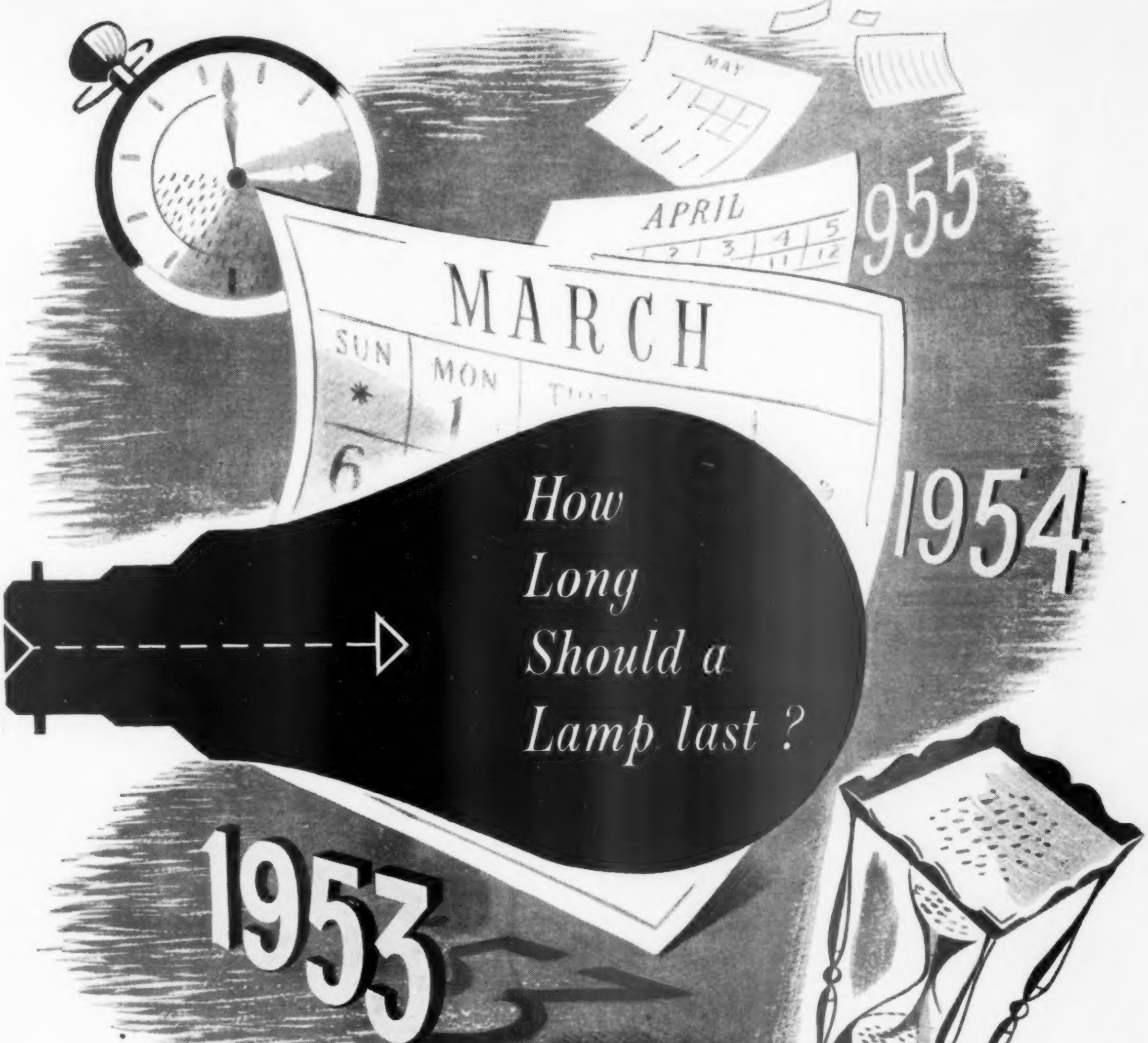
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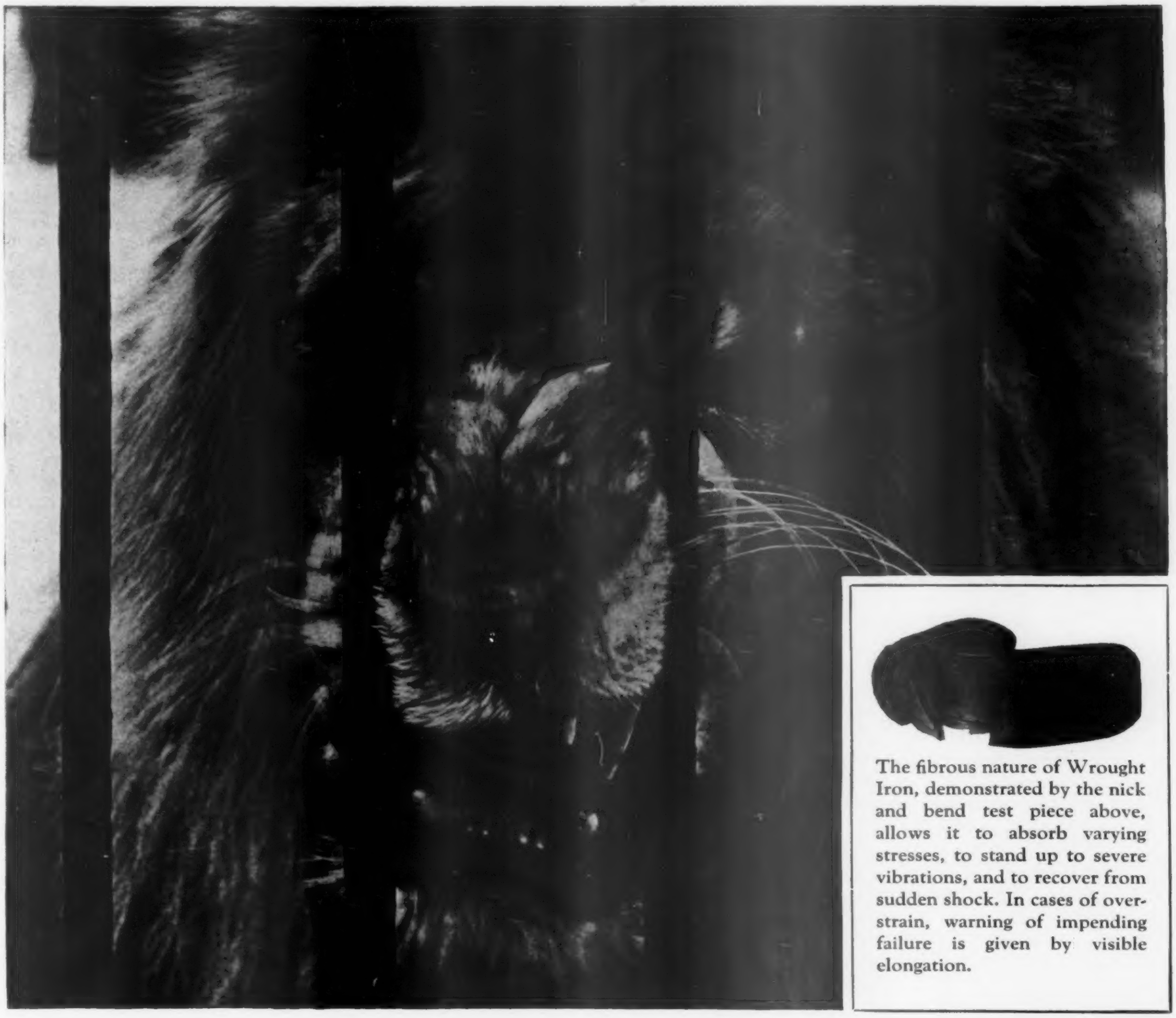

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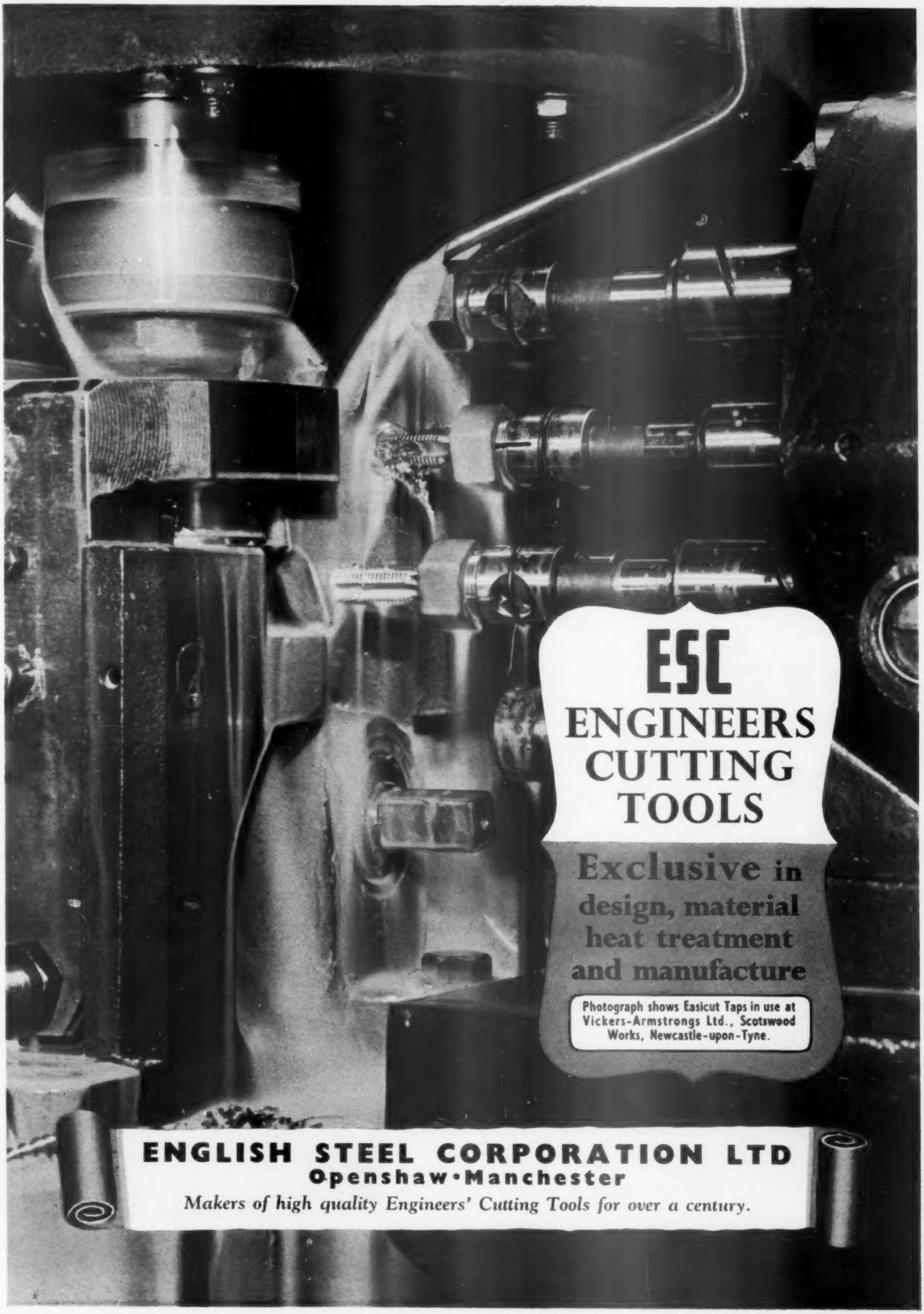

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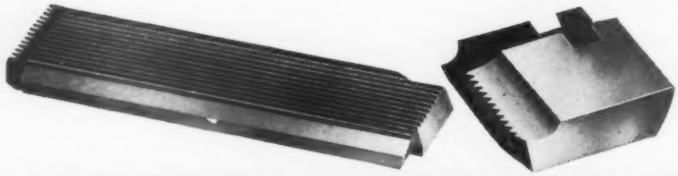

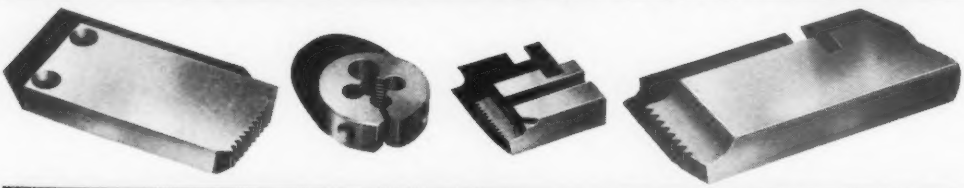

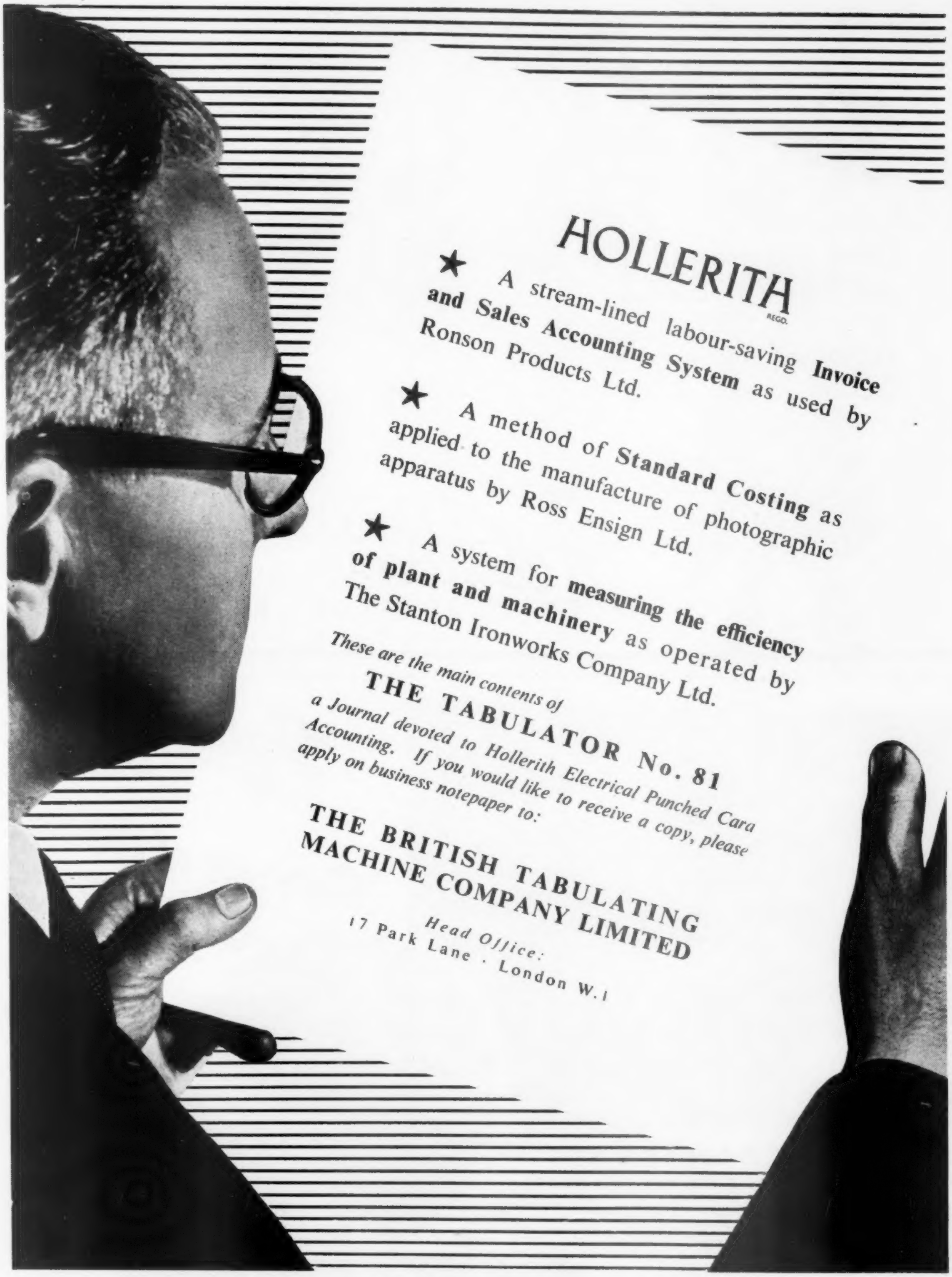

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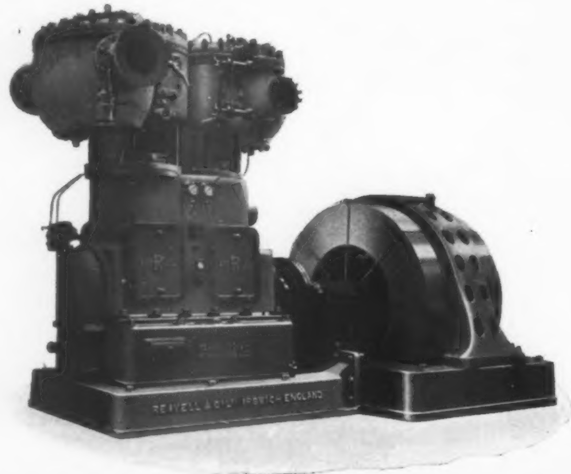

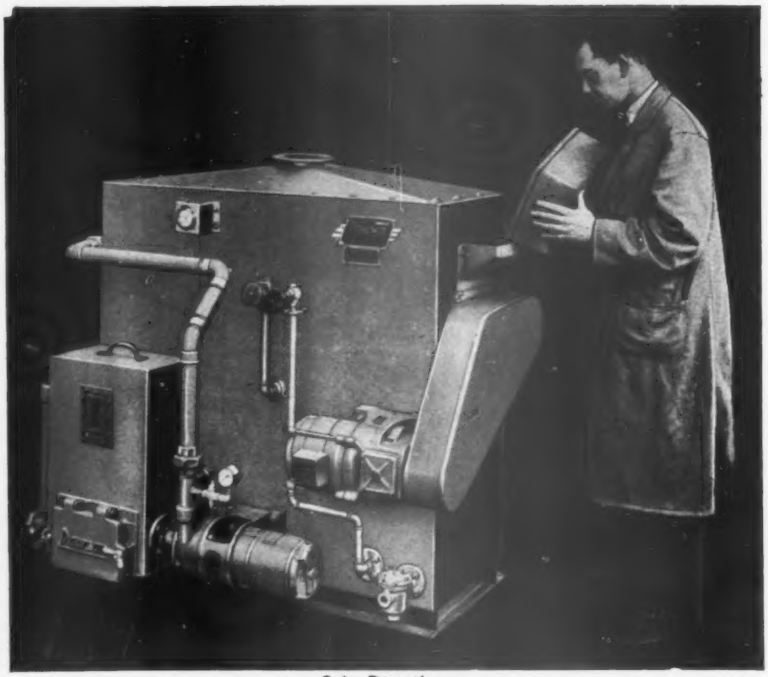

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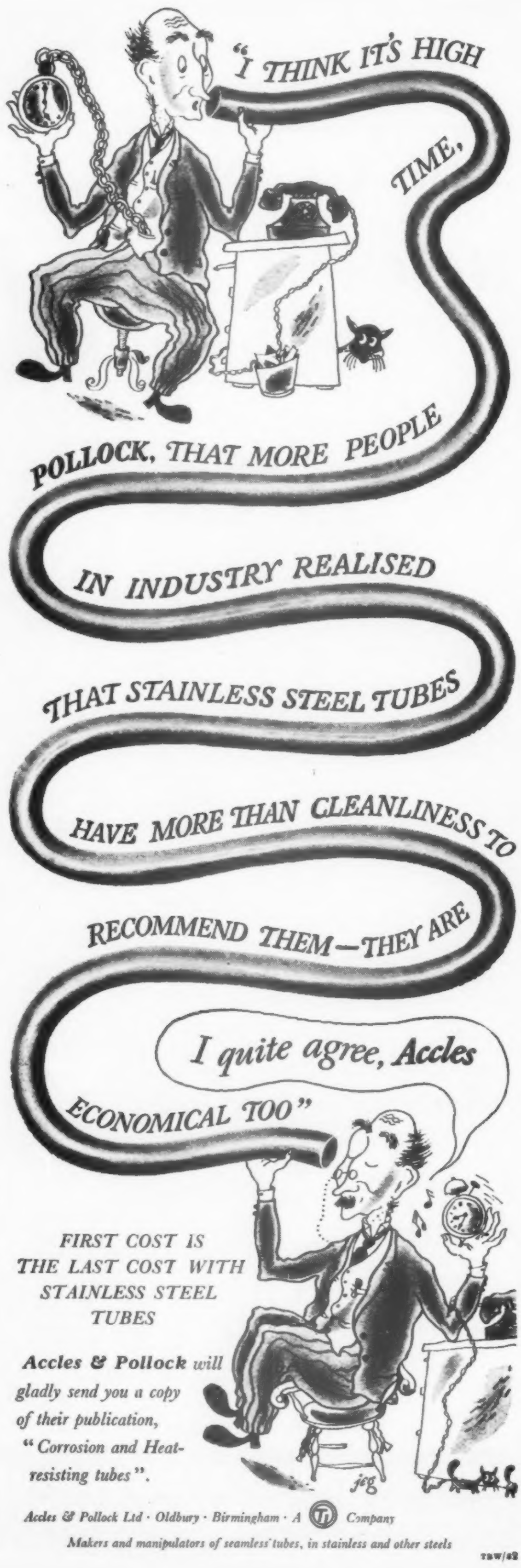

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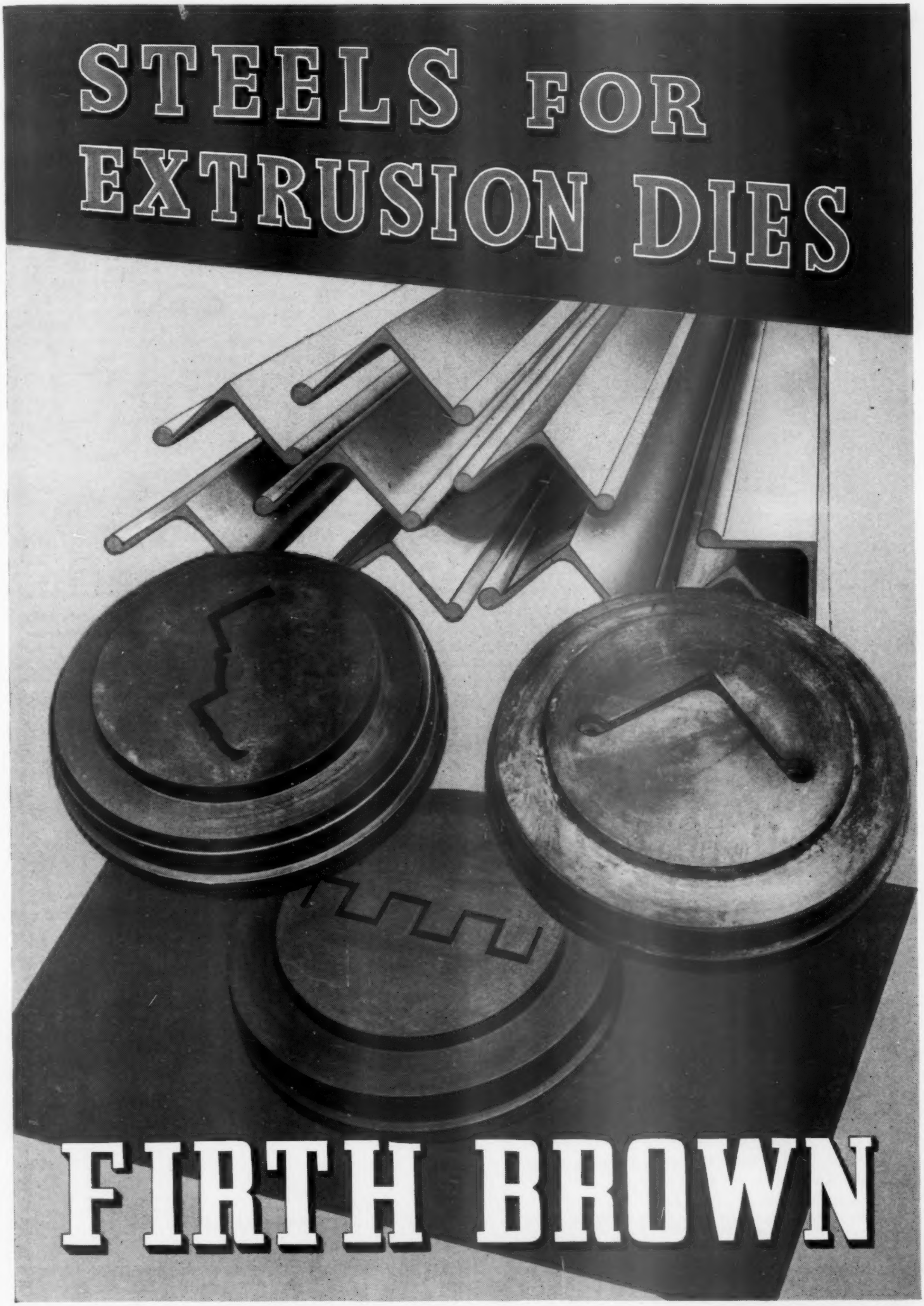
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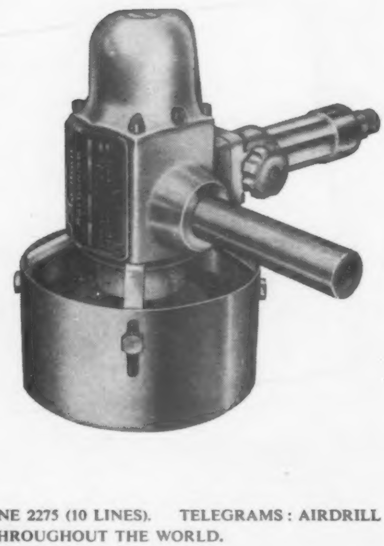

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